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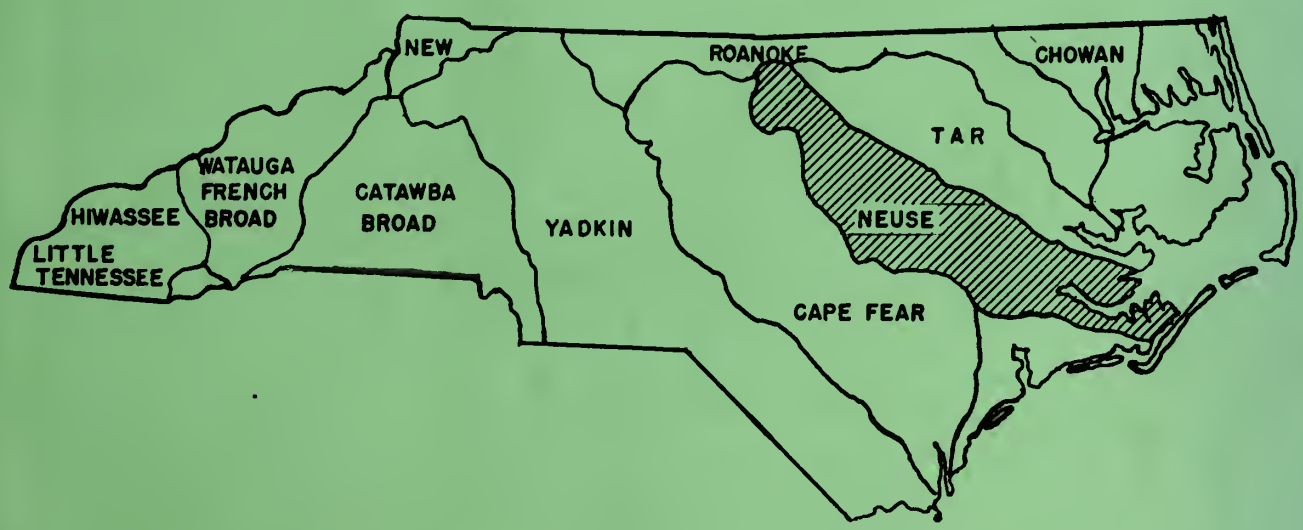
WATER RESOURCES OF NORTH CAROLINA

NEUSE RIVER BASIN



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FOREWORD

This publication comprises Volume II of a series of eleven volumes, containing information regarding the water resources of North Carolina. Volume I, pertaining to the State as a whole, was published in January 1955. Volumes III - XI, inclusive, will contain detailed information and data pertaining to the Yadkin, Roanoke, Chowan, Tar-Pamlico, Cape Fear, Catawba-Broad, Hiwassee-Little Tennessee, Watuaga-French Broad, and New River Basins. When the contemplated series are completed, information for the entire State will be available to assist in the orderly planning and development of the water facilities required for municipal and industrial expansion, and for the expansion of the uses of water in agriculture; to guide the Neuse River Watershed Authority, established by the General Assembly of North Carolina in 1953, and similar agencies which may be created in the future, in accomplishing their purposes; and to provide aid to the Board of Water Commissioners of the State of North Carolina, created by the 1955 Session of the General Assembly of North Carolina.

It is hoped that this publication will assist in the location, development, and expansion of municipal, industrial, agricultural, and other water supplies, and will serve as a guide for the future study of water resources in the Neuse River Basin.

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Material for the various chapters of this publication was obtained from the following sources:

Chapters I and XIII -- House Document No. 500, 72nd Congress, 2nd Session, and House Document No. 327, 77th Congress, 1st Session.

Chapters II - V, inclusive -- Farmers Home Administration, U. S. Department of Agriculture, North Carolina Department of Labor, Division of Mineral Resources, N. C. Department of Conservation and Development, North Carolina Almanac and State Industrial Guide, Ground Water Branch of U. S. Geological Survey, North Carolina State Board of Health, Reports from North Carolina Municipal Waterworks Superintendents, Division of State Parks, N. C. Department of Conservation and Development, North Carolina Recreation Commission, North Carolina Wildlife Resources Commission.

Chapter VI -- House Document No. 500, 72nd Congress, 2nd Session.

Chapters II, III, VII, VIII, and IX -- From a report in preparation by the United States Geological Survey, "Water Resources of the Neuse River Basin", by G. A. Billingsley, R. E. Fish, and R. G. Schipf. This report was prepared by the Water Resources Division of the U. S. Geological Survey, with the financial assistance of the Division of Water Resources, Inlets, and Coastal Waterways, North Carolina Department of Conservation and Development. The report was prepared under the direct supervision of E. B. Rice, district engineer (Surface Water Branch), H. E. LeGrand, district geologist (Ground Water Branch), and G. A. Billingsley, district chemist (Quality of Water Branch). Many individuals in the Water Resources Division contributed to the preparation of this report, but the principal authors, G. A. Billingsley, chemist, R. E. Fish, hydraulic engineer, and R. G. Schipf, geologist, represent the varied skills of the Water Resources Division that were concentrated on processing and analyzing the data upon which this report is based. Most of the data summarized in this report have been collected over a period of many years by the U. S. Geological Survey in cooperation with the following agencies:

North Carolina Department of Conservation and Development
- Division of Water Resources, Inlets and Coastal Waterways
- Division of Mineral Resources

North Carolina State Board of Health

Corps of Engineers, U. S. Army, Wilmington, N. C., District

Other data and information presented in the report are based on data collected by, in cooperation with, or are from technical reports or publications of, the U. S. Weather Bureau, North Carolina State Stream Sanitation Committee, and the North Carolina State Highway and Public Works Commission.

Material in Chapter IX, additional to that contained in the report, was obtained from the North Carolina State Stream Sanitation Committee.

Chapter X -- State Conservationist, Soil Conservation Service, U. S. Department of Agriculture.

Chapter XI - 1953 Session Laws, General Assembly of North Carolina Neuse River Watershed Authority, State Conservationist, Soil Conservation Service, U. S. Department of Agriculture.

Chapter XII - Water Resources Development by the Corps of Engineers in North Carolina - - Division Engineer, South Atlantic Division, Corps of Engineers, U. S. Army, 1 January 1953.

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CHAPTER I-- DESCRIPTION OF WATERSHED

Main Stream--The Neuse River is formed by the confluence of the Eno and Flat Rivers in Durham County. These streams rise in the Piedmont Plateau in the north central part of the State and are of nearly equal size. The drainage area of the Neuse River at its beginning is 475 square miles. It flows in a general southeasterly direction through the Piedmont Region and Coastal Plain of North Carolina, emptying into Pamlico Sound. It is the second largest river basin lying entirely within the State of North Carolina, the first and third largest being the Cape Fear River and the Tar River, respectively. The total length of the Neuse River, including the Flat River, its longest arm, is approximately 300 miles. The area of its watershed is approximately 5,490 square miles.

Tributaries--Trent River is the first river of importance encountered as the Neuse River is ascended. This stream has its source in Lenoir County, in the Coastal Plain, and flows in a general easterly direction, joining the main stream from the right bank at New Bern. The elevation of the source of the Trent River is about 200 feet above mean sea level. It empties into the Neuse River at mean sea level. Its gradient is uniform and comparatively flat throughout. The drainage area of the Trent River is approximately 510 square miles. Its tributaries, from its mouth to its sources, include Brice Creek, Wilson Creek, Reedy Branch, Hayward Creek, Island Creek, Deep Gully, Mill Creek, Mill Run, Long Branch, Beaverdam Creek, Jumping Creek, Crooked Run, Musselshell Creek, Resolution Branch, Deep Bottom Branch, Beaver Creek, Heath Mill Run, Trace Branch, Rattlesnake Branch, Flat Swamp, Poplar Branch, Chinquapin Branch, Jack Cabin Creek, Mill Branch, Cypress Creek, Tuckahoe Swamp, and Joshua Branch.

Contentnea Creek, the largest tributary of the Neuse River, is formed by the confluence of Moccasin and Turkey Creeks in Wilson County. Most of the territory drained by this stream lies in the Coastal Plain. Its source tributaries, however, extend into the Piedmont Plateau. The stream flows in a southeasterly direction, paralleling Neuse River for a large portion of its length. It enters the main stream from the left bank, 18 miles below Kinston. The elevation of the source of Contentnea Creek is approximately 300 feet. The stream enters Neuse River at an elevation of 5 feet above mean sea level. Its fall above Wilson is irregular and quite steep in certain localities, consisting largely of pools and rapids. Below Wilson, its gradient is uniform and flat. The basin drained by Contentnea Creek embraces an area of approximately 1,000 square miles. Its tributaries from its mouth to the confluence of Moccasin and Turkey Creeks, source tributaries, include Little Contentnea Creek, Sandy Run, Middle Swamp, Wheat Swamp, Polecat Creek, Swamp Creek, Mussel Run, Rainbow Creek, Panther Swamp, Tyson Marsh, Mill Run, Fort Run, Nahunta Swamp, Appletree Run, Beaman Run, Toisnot Swamp, Whiteoak Swamp, Black Creek, Turner Swamp, Aycock Swamp, Great Swamp, Hominy Swamp, and Bloomery Swamp. Tributaries of Turkey Creek, from its confluence with Moccasin Creek to its sources, include Beaverdam Branch, Haw Branch, and Big Branch.

Little River, another important tributary of the Neuse River, rises in the Piedmont Region in Franklin County. Its general course is also southeasterly and parallel to that of the main stream. This tributary enters the Neuse River from the left bank at Goldsboro. The elevation of the source of Little River is about 400 feet and, of its mouth, 48 feet.

Its gradient is similar to that of Contentnea Creek. The basin drained by Little River has an area of 316 square miles. Its tributaries, from its mouth to its sources, include Spring Branch, Little Buffalo Creek, and Buffalo Creek.

Flat River, the lesser of the two source tributaries of the Neuse River, rises in Person County in the central Piedmont Region. This stream also flows in a southeasterly direction. The elevation of its source is approximately 600 feet and, of its mouth, 240 feet. Flat River has a very steep gradient, and, throughout its length, there are numerous falls and rapids. The drainage area of this stream is 218 square miles. Its tributaries, from its confluence with Eno River to its sources, include Dry Creek, Dial Creek, and Deep Creek.

Eno River, the larger source tributary of the Neuse River has its beginning also in Person County. It flows in an easterly direction through the greater part of its length. The elevation of its source is approximately the same as that of Flat River, and its gradient is also similar. The area of its watershed is 258 square miles. Its tributaries, from its confluence with Flat River to its sources, include Little River, Cabin Branch, Mountain Creek, South Fork of Little River, North Fork of Little River, Crooked Creek, Seven Mile Creek, (Durham County), Strouds Creek, Seven Mile Creek (Orange County), and McGowan Creek.

The tributaries of Neuse River, other than Trent River, Contentnea Creek, Little River, Flat River, and Eno River, are small and relatively unimportant, and include the following;

Between the mouth of Neuse River and Trent River--Slocum Creek, Goose Creek, upper Broad Creek, and Duck Creek.

Between Trent River and Contentnea Creek--The Gut, Batchelders Creek, Rollover Creek, Swift Creek, Little Swift Creek, Fisher Swamp, Beaverdam Swamp, Pine Tree Swamp, Palmetto Swamp, Creeping Swamp, Clayroot Swamp, Indian Wells Swamp, Turkey Quarter Creek, Cove Creek, Mill Branch, and Halfmoon Creek.

Between Contentnea Creek and Little River--Mosleys Creek, Tracey Swamp, Stonyton Creek, Jericho Run, Briery Run, Falling Creek, Bear Creek, Dailys Creek, Walnut Creek, Sleep Creek and Stony Creek.

Between Little River and the confluence of Eno and Flat Rivers--Beaverdam Creek (north of Neuse River), Beaverdam Creek (south of Neuse River), Moccasin Swamp, Burden Creek, Mill Creek (Southern Johnston County), Bowdy Creek, Black Creek, Saxarissa Swamp, Reedy Branch, Pole Branch, Dicks Branch, McCullers Branch, Hooks Branch, Steep Hill Creek, Swift Creek, Little Creek, Whiteoak Creek, Little Branch, Reedy Branch, Mill Creek (Northern Johnston County), Mark's Creek, Poplar Creek(Wake County), Walnut Creek, Crabtree Creek, Hodges Creek, Powell Creek, Perry Creek, Tomb Creek, Smiths Creek, Richland Creek, Horse Creek, Water Fork, Mud Branch, Lower Barton's Creek, Upper Barton's Creek, Newlight Creek, Buckhorn Creek, Beaverdam Creek, Little Beaverdam Creek, Ledge Creek, Lick Creek, Aurel Creek, Rocky Branch, Martin Branch, Chunky Pipe Creek, Little Lick Creek, Panther Creek, and Ellerbe Creek.

Relation to other Streams-- The Neuse River has a course practically parallel to that of the Pamlico and Tar Rivers (one stream) to the

north. Its navigable reach is connected with a similar reach on that stream, and with the Cape Fear River to the south by the Atlantic Intracoastal Waterway between Norfolk, Virginia, and the St. Johns River, Florida.

Gradient of the Stream -- The Neuse River has a total fall, from its furthermost source to its mouth, of approximately 600 feet. Its fall by long reaches is as follows: From its furthermost source to the confluence of the Eno and Flat Rivers, 360 feet; from that point to the Falls of the Neuse in Wake County, approximately 12 air-line miles north of Raleigh, 27 feet; Falls of the Neuse, 23 feet; from these falls to Smithfield, 88 feet; and from Smithfield to the mouth of the stream, 102 feet. Throughout these reaches, except at the Falls of the Neuse and at Milburnie, on U. S. Highway 64 about 5.5 miles east of Raleigh, the gradient of the stream is very uniform. The Neuse River has practically no tidal reach. The portion between New Bern and the mouth, however, is subject to fluctuations in height caused by winds.

Description of Basin -- The drainage basin of the Neuse River is oblong in shape, its greatest width being about 46 miles. The stream in its upper reaches approximately bisects its drainage area. In the middle portion, it flows near its southern boundary. In the lower reaches between Kinston and Contentnea Creek, the river makes almost a right angle turn to the northeast and, from this latter point to its mouth, again flows in the center of its watershed.

Agricultural Development -- A large proportion of the lands contained in the Neuse River Basin are used for agricultural purposes. The principal crops grown are cotton, tobacco, peanuts, potatoes, and truck produce. Tobacco is the most important crop. The City of Wilson, on the main line of the Atlantic Coast Line Railroad between Contentnea Creek and the northern boundary of the Neuse River Basin, is one of the largest tobacco markets in the world. Peaches and other fruits are raised in the sandy uplands. Dairying is a growing industry in the Piedmont section. Except for milch cows, the livestock industry is of little importance, although some hogs are raised in the Coastal region.

Lumbering -- Lumbering is carried on over the entire Neuse Watershed. This industry is not of great importance, however, except in the Coastal Plain. The principal merchantable timbers are long and short leaf pine, gum, juniper, and cypress. Turpentine is extracted in large quantities in the Coastal Plain.

Manufacturing -- The Neuse River Basin is primarily an agricultural region, although manufacturing is a growing industry, particularly in the Piedmont section. The principal products manufactured are tobacco products, textiles, fertilizers, wood products, food stuffs and clay products. Of these, the manufacture of tobacco is by far the most important. The textile industry ranks second.

Minerals and Mining -- The mineral resources of the Neuse River Basin are relatively unimportant. Among the metals, gold, copper, lead, zinc, and iron are found in small quantities. None of these minerals are produced commercially. The nonmetallic minerals consist chiefly of granites, gneisses, and quartz in the Piedmont region, and marl, limestone, clay, sand, and gravel in the Coastal Plain. Many excellent types of building stones are found throughout the area. There exists excellent material in Jones

and Craven Counties, which may be used in the manufacture of Portland cement. The marl in Craven County has been used to a limited extent in the manufacture of fertilizer. None of these products are mined extensively. In general, they are produced only as local demands require.

Transportation Facilities — This area is served by a network of railroads, the principal lines being the Atlantic Coast Line Railroad, the Seaboard Air Line Railroad, the Southern Railway, and the Norfolk Southern Railway. Paved State and U. S. highways connect all county seats and important towns. There are also many other improved roads. Numerous truck and bus lines ply these highways. Water-transportation facilities are discussed in the navigation chapter of this publication.

Principal Cities and Towns — The principal cities and towns in the Neuse River Basin, as determined by the 1950 census, are as follows:

City or Town	County	Population
Durham	Durham	71,311
Raleigh	Wake	65,679
Wilson	Wilson	23,010
Goldsboro	Wayne	21,454
Kinston	Lenoir	18,336
New Bern	Craven	15,812
Smithfield	Johnston	5,574
Roxboro	Person	4,321
Mount Olive	Wayne	3,732
Wake Forest	Wake	3,704
Farmville	Pitt	2,942
Hillsboro (including West Hillsboro)	Orange	2,785
Selma	Johnston	2,639
Ayden	Pitt	2,282
Clayton	Johnston	2,229
La Grange	Lenoir	1,852
Cary	Wake	1,446
Fremont	Wayne	1,395
Zebulon	Wake	1,378
Wendell	Wake	1,253
Garner	Wake	1,180
Kenly	Johnston	1,129

Durham is the most important industrial city and has large tobacco and textile interests. Raleigh, the State capital, is a growing distributing, banking, and shopping center. New Bern is an inland port, connected by means of the Atlantic Intracoastal Waterway with the large cities of the Atlantic Seaboard. These cities and Wilson, mentioned above under "Agricultural Development", Goldsboro, Kinston, Smithfield, Roxboro, and Hillsboro are county seats. Durham, Raleigh, and Wake Forest are educational centers, noted for Duke University, North Carolina State College, and Wake Forest College, respectively.

Topography -- The topography of the basin drained by the Neuse River can be roughly divided into two physical divisions, which are known locally as the Piedmont Plateau and the Coastal Plain.

The Piedmont Plateau consists largely of rolling hills and deeply eroded valleys, the tops of the hills being the remnants of a former land surface, worn down by erosion nearly to a plain. This region extends from the sources of the stream and beyond to a northeast and southwest line roughly defined by the main line of the Atlantic Coast Line Railroad between Wilson and Fayetteville, situated in the Cape Fear River valley. The elevation of the Piedmont Plateau varies in the Neuse River Basin from 800 feet at the headwaters of the stream to 200 feet, where it merges into the Coastal Plain. It is in this physical division that most of the reservoir and power sites are found.

The remainder of the drainage area of the Neuse River is included in the Coastal Plain. The topography in this region varies from rolling sand hills at its western boundary to almost level land as it approaches the Atlantic Ocean, its larger portion being gently rolling in character. The stream valleys are wide, with much overflow and marsh land. Because of these features, practically no reservoir or power sites are available in the Coastal Plain.

Geology -- The surface mantle of the Piedmont Plateau consists largely of soils of slate or granite origin, the principal types being composed of sand and clay in varying mixtures. The top soils are usually shallow and are underlain by slate, sandstone, quartz, and granite or other igneous material. The large streams have, in general, cut their beds down to the basement rocks, which are of igneous origin. Faults and fractures of the earth's surface are unusual in this region. Good foundations for dams of great weight exist almost universally throughout this area. Impounding reservoirs, located here, should be capable of holding water without danger of large seepage losses through subterranean fissures.

The Coastal Plain is composed largely of sand, gravel, and marine deposits of comparatively recent origin. The whole is underlain by the basement rocks. The depth to these rocks increases toward the coast, their general dip being in that direction. Where these rocks lie too deep below the stream beds to place a dam thereon, poor foundation conditions for heavy structures are found. Reservoirs in this area would doubtless lose considerable quantities of water through seepage when first constructed. Such losses would decrease materially in time, however, as silt would be deposited as an impervious layer on their floors.

Forest Cover -- The watershed of the Neuse River was formerly heavily forested with virgin stands of hardwoods and pines. Of the original forest cover, little pine remains, except in the Coastal Region, and the supply of hardwoods in commercial quantities has also been largely exhausted. However, much of this area, which was once cleared and cultivated, has been allowed to revert to forests, this second growth consisting largely of short-leaf pine. It is estimated that 50 per cent of the entire basin is forested, although about 70 per cent of it is classed as woodland area. The principal species of timber found are oak, hickory, ash, gum, juniper, cypress, and several varieties of pine, the short-leaf type predominating.

State Forests and Nurseries -- No public forest preserves exist in the Neuse River Basin. The Division of Forestry, Department of Conservation and Development, operates the State's three forest tree nurseries, one in Johnston County, one in Wayne County, and one in Henderson County. These

three nurseries have a total estimated capacity of approximately 40 million seedlings annually. The tree seedlings are sold for windbreaks, erosion control, and forest plantings at varying prices ($3.00 per thousand, f.o.b. destination, for the several species of pine).

The State Forest Nursery near Clayton in Johnston County, about 1½ miles southeast of the Neuse River, has an estimated production of approximately 10 million seedlings. Due to the heavy demands in the past, this nursery has been over-producing, at the rate of 15 to 18 million seedlings annually and at the expense of soil depletion. With the production at the new nursery, established near Goldsboro on Little River, less seedlings will be raised at the Clayton Nursery.

The new nursery is known as the Little River State Forest Nursery. It is estimated that this nursery will have an annual capacity of 25 million seedlings when it is fully developed.

Production at the Holmes Nursery near Hendersonville in the French Broad River Basin has been increased, and approximately five million seedlings, mostly white pine and some yellow poplar, are raised annually in this nursery.

State Parks -- The Division of State Parks, Department of Conservation and Development, operates, maintains, and administers nine State Parks and six State Historical Parks in North Carolina. Of the nine State Parks, three are located in the Neuse River Basin, namely, Cliffs of the Neuse State Park, William B. Umstead State Park, and Reedy Creek State Park. Information regarding these parks may be found in the chapter of this publication pertaining to use of water for recreation.

Watershed Boundary -- The boundary line of the Neuse River Watershed, in a clockwise direction, extends generally as follows:

Beginning at the bridge, on the highway between the Town of Atlantic and the Towns of Roe and Lola in Carteret County and crossing the channel between Thoroughfare Bay and Cedar Island Bay.

Thence southwest about 9 miles and west about 15 miles to State Highway No. 101 at a point on the ridge between Harlowe Creek and Clubfoot Creek:

Thence about 15 miles west along the Carteret-Craven boundary line;

Thence north between the source of Slocum Creek and the eastern edge of Ellis Lake;

Thence east between Ellis Lake and Long Lake, northwest between Long Lake and Great Lake, and east between Catfish Lake, and the source of Island Creek, a tributary of the Trent River, to a point on the Atlantic Coast Line Railroad about three miles north of Maysville;

Thence east to the boundary between Jones and Onslow Counties, approximately in the middle of Whiteoak Swamp;

Thence southwest and northwest, between the source of Cowhorn Swamp, a tributary of New River, and the Source of Cypress Creek, a tributary of Trent River, and across the Dover and Southbound Railroad near Petersburg;

Thence generally parallel to Trent River and Tuckahoe Creek from Petersburg to Pink Hill;

Thence generally along the northern side of the boundary between Lenoir and Duplin Counties, and Wayne and Duplin Counties, to Mount Olive;

Thence along State Highway No. 55 to Newton Grove;

Thence along State Highway No. 50 to Benson;

Thence generally north of the boundaries between Johnston and Harnett Counties, and Wake and Johnston Counties to Fuquay-Varina;

Thence east of, and generally parallel to, the Durham and Southern Railroad between Fuquay-Varina and Durham;

Thence along the Southern Railway to University Station;

Thence along the divide between the Haw River and the Eno River to Efland and Cedar Grove;

Thence north to the boundary line between Orange and Caswell Counties;

Thence north, generally parallel to, and east of Sugartree Creek to a point about four miles northeast of Leasburg;

Thence east and southeast through Roxboro to Center Grove;

Thence southeast, crossing the Southern Railway about half-way between Providence and Stem, and crossing the branch line of the Seaboard Air Line Railroad from Durham to Henderson at a point about halfway between the towns of Hester and Tar River, to a point on the main line of the Seaboard Air Line Railroad about two miles north of Youngsville;

Thence, in a generally southeasterly direction, along the divide between Beaverdam Creek and Ford Creek, Newlight Creek and Cedar Creek, Little River and Crooked Creek, Moccasin Creek and Crooked Creek, Turkey Creek and Tar River, Toisnot Swamp and Tar River, and Toisnot Swamp and Town Creek to a point on the Atlantic Coast Line Railroad about one mile north of Wilson;

Thence along the divide between Whiteoak Swamp and Otter Creek, Little Contentnea Creek and Otter Creek, Little Contentnea Creek and Tar River, Fork Swamp and Tar River, Clayroot Swamp and Chicod Creek, Palmetto Swamp and Chicowinity Creek, Upper Broad Creek, and Durham Creek, Goose Creek and Durham Creek, Bay River and Durham Creek, and Bay River and South Creek, and thence east to Mouse Harbor between Pamlico Point and Porpoise Point, passing generally through or near the towns of Wilbanks, Fountain, California, Arthur, Blackjack, Bragaw, Rover, Blount Creek, Aurora, Hobucken, and Lowland.

Neuse River Basin Streams - - There follows a list, alphabetically arranged, of streams in the Neuse River Basin, the names of which are shown on available maps. There are a great number of streams shown on such maps, the names of which are not indicated. There are shown on the following list the stream into which each of the streams, alphabetically placed on the list, flows, and also the county in which the junction of the corresponding two streams is located.

It is believed that this list will be helpful to interested persons in quickly locating on a county, topographical, or other map any stream included in the list, and also to trace the course of the stream throughout the basin. For example, let it be assumed that information regarding Beaverdam Branch is desired. In the following list, it is indicated that Beaverdam Branch joins Turkey Creek in Nash County. Examination of the State Highway and Public Works Commission map of Nash County reveals that the junction of Beaverdam Branch and Turkey Creek occurs in the southwestern corner of Nash County, and that the former rises near the Norfolk Southern Railroad right-of-way at Middlesex. After looking at the information in the following list regarding Turkey Creek and subsequent receiving streams, it is found that water from Beaverdam Branch flows in Turkey Creek to the latter's junction with Contentnea Creek in Wilson County, thence in Contentnea Creek to its mouth in Neuse River in Lenoir County, and thence in Neuse River, which forms the boundary between Pamlico County and Carteret and Craven Counties, and empties into Pamlico Sound.

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Adams Creek	Neuse River	Craven
Adkin Creek	Neuse River	Lenoir
Alderidge Creek	South Flat River	Person
Appletree Swamp	Nahunta Swamp	Greene
Aurel Creek	Lick Creek	Durham
Austin Creek	Smiths Creek	Wake
Aycock Swamp	Black Creek	Wilson
Back Creek	Adams Creek	Craven
Ball Creek	Bay River	Pamlico
Bassol Creek	Middle Creek	Wake
Batchelders Creek	The Gut	Craven
Bawdy Creek	Neuse River	Johnston
Bawdy Swamp	Bawdy Creek	Johnston
Bay River	Neuse River	Pamlico
Beamun Run	Contentnea Creek	Greene
Bear Creek	Neuse River	Lenoir
Bear Creek	Bay River	Pamlico
Beard Creek	Neuse River	Pamlico
Beaver Creek	Trent River	Jones
Beaverdam Branch	Middle Creek	Johnston
Beaverdam Branch	Turkey Creek	Nash
Beaverdam Creek	Toisnot Swamp	Nash
Beaverdam Creek (B)	Neuse River (left bank)	Wayne
Beaverdam Creek (A)	Neuse River (right bank)	Wayne
Beaverdam Creek (C)	Neuse River	Wake (NE)
Beaverdam Creek (D)	Neuse River	Wake (SE)
Beaverdam Creek	Moccasin Creek	Nash
Beaverdam Creek	Trent River	Jones

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Beaverdam Swamp	Little Swift Creek	Craven
Bernal Branch	Hannah Creek	Johnston
Big Arms Creek	Marks Creek	Johnston
Big Branch	Turkey Creek	Nash
Big Branch	Walnut Creek	Wake
Black Creek	Neuse River	Johnston
Black Creek	Contentnea Creek	Wilson
Black Swamp	Little Contentnea Creek	Pitt
Bloomery Swamp	Contentnea Creek	Wilson
Briar Creek	Stirrup Iron Creek	Wake
Brice Creek	Trent River	Craven
Briery Run	Stonyton Creek	Lenoir
Broad Creek	Neuse River	Pamlico
Brown Creek	Broad Creek	Pamlico
Buck Branch	Reedy Branch	Wake
Buckhorn Creek	Newlight Creek	Wake
Buck Swamp	Thoroughfare Swamp	Wayne
Buffalo Branch	Middle Creek	Johnston
Buffalo Creek	North Fork Little River	Durham
Buffalo Creek	Little River	Johnston
Burden Creek	Moccasin Swamp	Wayne
Bushy Fork Creek	South Flat River	Person
Byrd's Creek	South Flat River	Person
Cabin Branch	Little River	Durham
Cahoogue Creek	Hancock Creek	Craven
Camp Branch	Middle Creek	Wake
Camp Branch	Black Creek	Johnston
Camp Creek	Flat River	Durham
Cat Tail Creek	Little River	Johnston
Cedar Creek	Robertson Creek	Granville
Cedar Fork	Little River	Wake
Chappel Creek	Bay River	Pamlico
Chappels Creek	North Flat River	Person
Chinquapin Branch	Trent River	Jones
Chunky Pipe Creek	Neuse River	Durham
Clayroot Swamp	Swift Creek	Craven
Clubfoot Creek	Neuse River	Craven
Contentnea Creek	Neuse River	Lenoir
Cove Creek	Neuse River	Craven
Crabtree Creek	Neuse River	Wake
Creeping Swamp	Clayroot Swamp	Craven
Crooked Creek	Eno River	Durham
Crooked Run	Trent River	Jones
Cypress Creek	Trent River	Jones
Dailys Creek	Neuse River	Lenoir
Dawson Creek	Neuse River	Pamlico
Deep Bottom Branch	Beaver Creek	Jones
Deep Creek	Flat River	Durham
Deep Gully	Trent River	Jones
Deep Run	Southwest Creek	Lenoir
Dial Creek	Flat River	Durham
Dickens Creek	Knap of Reeds Creek	Granville
Dicks Branch	Black Creek	Johnston
Dry Creek	Flat River	Durham

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Duck Creek	Neuse River	Craven
Eagle Swamp	Contentnea Creek	Lenoir
East Branch	Swift Creek	Lenoir
East Fork Creek	Goose Creek	Pamlico
Eastman Creek	South River	Craven
Ellerbe Creek	Neuse River	Durham
Eno River	Neuse River	Durham
Exum Mill Branch	The Slough	Wayne
Falling Creek	Neuse River	Lenoir
Falling Creek	Beaverdam Creek	Wayne
Fisher Swamp	Beaverdam Swamp	Craven
Five Canals	Back Creek	Craven
Flat River	Neuse River	Durham
Flat Swamp	Beaver Creek	Jones
Fork Swamp	East Branch	Lenoir
Fort Run	Contentnea Creek	Greene
Fowlers Mill Creek	Little River	Wake
Gale Creek	Bay River	Pamlico
Garbacon Creek	Neuse River	Craven
Goose Creek	Neuse River	Pamlico
Goss Swamp	Toisnot Swamp	Wilson
Great Swamp	Black Creek	Wilson
Greens Creek	Neuse River	Pamlico
Grindle Creek	Neuse River	Pitt
Groundnut Creek	Falling Creek	Lenoir
Guffy Branch	Juniper Branch	Wake
Guffy Branch	Middle Creek	Johnston
Gum Creek	Falling Creek	Lenoir
Halfmoon Creek	Neuse River	Craven
Hancock Creek	Neuse River	Craven
Hannah Creek	Mill Creek	Johnston
Hardy Mill Branch	Black Creek	Johnston
Hare Creek	Crabtree Creek	Wake
Hayward Creek	Trent River	Craven
Heath Mill Run	Beaver Creek	Jones
Hodges Creek	Neuse River	Wake
Hominy Creek	Little River	Wake
Hominy Swamp	Contentnea Creek	Wilson
Hooks Branch	Black Creek	Johnston
Hornpipe Creek	Southwest Creek	Lenoir
Horse Branch	Southwest Creek	Lenoir
Horse Creek	Neuse River	Wake
House Creek	Crabtree Creek	Wake
Island Creek	Trent River	Jones
Inland Waterway	Adams Creek	Craven
Inland Waterway	Gale Creek	Pamlico
Jack Cabin Creek	Trent River	Jones
Jericho Run	Stonyton Creek	Lenoir
Joshua Branch	Trent River	Jones
Jumping Creek	Trent River	Jones
Jumping Run	Falling Creek	Lenoir
Jumping Run	Mill Creek	Johnston
Juniper Branch	Middle Creek	Wake
Juniper Run	Mill Creek	Johnston
Juniper Swamp	Hannah Creek	Johnston

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Kershaw Creek	Greens Creek	Pamlico
Knap of Reeds Creek	Neuse River	Granville
Laurel Creek	Lick Creek	Durham
Ledge Creek	Neuse River	Wake
Lick Creek	Neuse River	Durham
Little Beaverdam Creek	Beaverdam Creek	Wake
Little Black Creek	Black Creek	Johnston
Little Branch	Neuse River	Johnston
Little Briar Creek	Briar Creek	Wake
Little Buffalo Creek	Little River	Johnston
Little Contentnea Creek	Contentnea Creek	Greene
Little Creek	Swift Creek	Johnston
Little Creek	Little River	Johnston
Little Lick Creek	Chunky Pipe Creek	Durham
Little Swamp	Mill Creek	Johnston
Little Swamp	Toisnot Swamp	Nash
Little Swift Creek	Swift Creek	Craven
Little River	Neuse River	Wayne
Little River	Eno River	Durham
Long Arm	Mark's Creek	Johnston
Long Branch	Trent River	Jones
Long Creek	Neuse River	Craven
Long Creek	Little River	Johnston
Lower Bartons Creek	Neuse River	Wake
Marks Creek	Neuse River	Johnston
Marsh Swamp	Contentnea Creek	Wilson
Martins Branch	Lick Creek	Durham
McCullers Branch	Black Creek	Johnston
McGowan Creek	Eno River	Orange
Middle Creek	Neuse River	Johnston
Middle Swamp	Little Contentnea Creek	Greene
Mill Branch	Cove Creek	Craven
Mill Branch	Trent River	Jones
Mill Branch	Middle Creek	Johnston
Mill Creek	Neuse River	Johnston
Mill Creek	Trent River	Jones
Mill Run	Trent River	Jones
Mill Run	Contentnea Creek	Greene
Mill Stone Creek	Bloomery Swamp	Wilson
Mine Creek	Crabtree Creek	Wake
Moccasin Creek	Neuse River	Johnston
Moccasin Creek	Contentnea Creek	Wilson
Moccasin Creek	Raccoon Swamp	Johnston
Mosley Creek	Falling Creek	Lenoir
Mosleys Creek	Neuse River	Lenoir
Mountain Creek	Little River	Durham
Mud Branch	Horse Creek	Wake
Mussel Run	Contentnea Creek	Greene
Musselshell Creek	Trent River	Jones
Nahunta Swamp	Contentnea Creek	Wayne
Neuse River	Pamlico Sound	------
Newlight Creek	Neuse River	Wake
North Flat River	Flat River	Person
North Fork	Little River	Durham

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Northwest Creek	Neuse River	Craven
Palmetto Swamp	Swift Creek	Craven
Panther Branch	Middle Creek	Wake
Panther Creek	Neuse River	Durham
Panther Swamp	Contentnea Creek	Greene
Perry Creek	Neuse River	Wake
Perry Creek	Little River	Wake
Picture Creek	Knap of Reeds Creek	Granville
Pinelog Branch	Little Contentnea Creek	Pitt
Pine Tree Swamp	Swift Creek	Craven
Pole Branch	Black Creek	Johnston
Polecat Branch	Neuse River	Johnston
Pole Creek	Contentnea Creek	Greene
Poplar Branch	Trent River	Jones
Poplar Creek	Neuse River	Wake
Powel Creek	Hodges Creek	Wake
Press Prong Creek	Turkey Creek	Nash
Raccoon Swamp	Neuse River	Johnston
Rainbow Creek	Contentnea Creek	Greene
Rattlesnake Branch	Beaver Creek	Jones
Ready Branch	Trent River	Jones
Reedy Branch	Swift Creek	Wake
Reedy Branch	Black Creek	Johnston
Reedy Branch	Little Branch	Johnston
Resolution Branch	Trent River	Jones
Richland Creek	Neuse River	Wake
Richland Creek	Crabtree Creek	Wake
Rock Fort Branch	Deep Creek	Durham
Rocky Branch	Lick Creek	Durham
Robertson Creek	Beaverdam Creek	Granville
Rollover Creek	Batchelders Creek	Craven
Sandy Run	Little Contentnea Creek	Greene
Sassarixa Swamp	Black Creek	Johnston
Seven Mile Creek	Eno River	Durham
Seven Mile Creek	Eno River	Orange
Sleep Creek	Neuse River	Wayne
Sleepy Creek	Neuse River	Johnston
Slocum Creek	Neuse River	Craven
Smith Creek	Neuse River	Pamlico
Smith Creek	Beaverdam Creek	Granville
Smiths Creek	Neuse River	Wake
Snipe Creek	Hare Creek	Wake
South River	Neuse River	Craven
South Flat River	Flat River	Person
South Fork	Little River	Durham
Southwest Creek	South River	Craven
Spring Branch	Little River	Johnston
Spring Creek	Bay River	Pamlico
Squirrel Creek	Neuse River	Lenoir
Steep Hill Creek	Middle Creek	Johnston
Stirrup Iron Creek	Crabtree Creek	Wake
Stone Creek	Mill Creek	Johnston
Stony Creek	Neuse River	Wayne
Stony Creek	Eno River	Orange

STREAM	RECEIVING STREAM	COUNTY IN WHICH JUNCTION OCCURS
Stony Fork	Hannah Creek	Johnston
Stonyton Creek	Neuse River	Lenoir
Strouds Creek	Eno River	Orange
Swift Creek	Neuse River	Craven
Swift Creek	Neuse River	Johnston
Sycamore Creek	Crabtree Creek	Wake
Terrible Creek	Middle Creek	Johnston
The Gut	Neuse River	Craven
The Slough	Nahunta Swamp	Wayne
Thoroughfare Swamp	Beaverdam Creek (A)	Wayne
Thunder Swamp	Thoroughfare Swamp	Wayne
Toisnot Creek	Contentnea Creek	Greene
Toisnot Swamp	Toisnot Creek	Wilson
Tomb Creek	Neuse River	Wake
Toms Creek	Neuse River	Wake
Trace Branch	Beaver Creek	Jones
Tracey Swamp	Mosleys Creek	Craven
Trent Creek	Bay River	Pamlico
Trent River	Neuse River	Craven
Tuckahoe Swamp	Trent River	Jones
Tucker Creek	Slocum Creek	Craven
Turkey Creek	Sycamore Creek	Wake
Turkey Creek	Contentnea Creek	Wilson
Turkey Creek	Crabtree Creek	Wake
Turkey Quarter Creek	Neuse River	Craven
Turner Swamp	Black Creek	Greene
Tyson Marsh	Contentnea Creek	Greene
Upper Bartons Creek	Neuse River	Wake
Upper Broad Creek	Neuse River	Craven
Vandemere Creek	Bay River	Pamlico
Vine Swamp	Beaver Creek	Jones
Walnut Creek	Neuse River	Wayne
Walnut Creek	Neuse River	Johnston
Water Fork	Horse Creek	Wake
Wells Swamp	Clayroot Swamp	Lenoir
West Bear Creek	Bear Creek	Lenoir
West Fork Creek	Goose Creek	Pamlico
Wheat Swamp Creek	Contentnea Creek	Lenoir
Whitelace Creek	Neuse River	Lenoir
Whiteoak Creek	Swift Creek	Johnston
Whiteoak Swamp	Toisnot Swamp	Wilson
Wilson Creek	Trent River	Craven
Wolfharbor Branch	Turkey Creek	Nash
Yellow Swamp	Thoroughfare Swamp	Wayne

CHAPTER II -- USE OF WATER FOR DOMESTIC AND MUNICIPAL PURPOSES

Population -- The total population of the Neuse River Basin increased from approximately 486,000 in 1940 to approximately 548,000 in 1950, an increase of approximately 12.6 per cent. During the same period, urban population increased from approximately 170,000 to approximately 220,000, an increase of approximately 29.4 per cent, and rural population increased from approximately 316,000 to approximately 328,000, an increase of approximately 3.8 per cent. It is estimated that the total population of the basin, at the end of 1954, was approximately 570,000, an increase of approximately 4 per cent during the past four years. The populations of the six largest cities in the basin, according to the last three censuses, is indicated in the following table.

CITY	1930	1940	1950
Durham	52,037	60,195	71,311
Raleigh	37,319	46,897	65,751
Wilson	12,613	19,234	23,010
Goldsboro	14,985	17,274	21,454
Kinston	11,363	15,388	18,366
New Bern	11,981	11,815	15,812

Availability of Water for Domestic and Municipal Use -- The Neuse River Basin has a propitious endowment of natural resources, of which water is the most important, because adequate supplies of water are necessary not only for maintenance of life but also for accomplishment of growth and development of the basin. Domestic and municipal use of water comprises the amounts of water used for drinking, bathing, washing clothes, sanitary facilities, fire-fighting, lawn-sprinkling, washing automobiles, air conditioning, and cleaning streets.

Use of Surface Water -- The per capita use of water is increasing rapidly, largely because of the fact that the people have accustomed themselves to liberal use of water and to modern manners of living. A comparison of increases in population served, average number of gallons per day, and per capita uses of water in seven cities in the Neuse River Basin, which utilize supplies of surface water, follows.

	Population served		Average Number of gallons per day		Gallons per capita per day average.	
CITY	1940	1950	1940	1950	1940	1950
Durham	61,000	73,500	5,940,300	8,150,000	97.2	111.0
Raleigh	56,000	70,000	4,150,000	6,850,000	74.0	97.5
Wilson	20,300	25,000	1,067,600	1,800,000	53.4	72.0
Goldsboro	20,000	24,000	1,139,000	2,213,900	57.0	92.2
Smithfield	3,500	5,700	142,000	346,000	40.6	62.9
Hillsboro	1,300	2,360	49,000	160,000	38.3	67.8
Creedmoor	100	1,000	1,700	34,210	17.0	34.2

1954 uses in the same cities were as follows.

CITY	Average number of gallons per day	Gallons per capita per day, average
Durham	8,823,000	117.6
Raleigh	8,606,200	117.0
Wilson	2,282,000	87.8

CITY	Average number of gallons per day	Gallons per capita per day, average
Goldsboro	2,532,400	101.3
Smithfield	708,100	120.0
Hillsboro	186,000	77.5
Creedmoor	45,500	45.5

The average daily per capita use of water in these six cities in 1940, 1950, and 1954 was 59.7, 82.2, and 99.4 gallons, respectively.

The following data pertain to State Hospitals in the Neuse River Basin, which have their own supplies of surface water.

State Hospital at Goldsboro, Including Dairy Farm

	1950	1954
Population served	3,909	
Average No. of gal./day	450,000	500,000
Cals./capita/day, peak month	120.5	127.9

State Hospital at Butner (estimated population served -- 3,500).
Monthly use in gallons

	1950	1954
January	10,054,000	19,875,000
February	8,388,000	19,834,000
March	10,328,000	20,632,000
April	9,089,000	19,474,000
May	10,522,000	17,988,000
June	12,371,000	20,487,000
July	12,507,000	24,485,000
August	9,839,000	26,243,000
September	11,745,000	29,112,000
October	11,426,000	24,291,000
November	9,701,000	21,521,000
December	10,963,000	22,046,000

The water plant of the State Hospital at Butner has a filter capacity of 3,000,000 gallons per day and includes a 2,000,000 gallon underground storage with a 1,000,000 gallon overhead tank to maintain pressure on the mains.

The Durham water plant has a nominal capacity of 15,560,000 gallons per day. With relatively minor adjustments, the capacity could be increased to 25,000,000 gallons per day. The City of Durham, at present, has no plans for increasing its water filtration plant.

The City of Goldsboro began the use of a new water plant, having a capacity of 3,000,000 gallons per day, in September, 1953. Engineers have advised the City that it will be necessary to enlarge the plant in 1959 or 1960.

During 1954, the capacity of the Smithfield water plant was increased from 500,000 to 1,000,000 gallons per day.

A well, not tested as of March 8, 1955, has been dug for the City of Wilson, which, in the past, has used surface water. If the test of this well indicates expected yield, five additional wells will be drilled. These wells will be used for raw water, which must pass through the City's filter plant. The City Council, as of March 8, 1955, were contemplating the construction of an additional raw-water reservoir on a nearby stream.

Since 1950, cities in the Neuse River Basin, using surface-water supplies, have increased the rated filtering capacities in million gallons per day, of their water plants as follows:

Durham	5.5
Raleigh	5.0
Wilson	3.0
Goldsboro	1.5
Smithfield	0.5

The City of Raleigh has constructed a raw-water reservoir, with a capacity of one billion gallons, on Swift Creek.

Use of Ground Water - - The average per capita use from ground water supplies in the Neuse River Basin is not as great as that from surface water supplies. Lack of large industries in areas in which ground water supplies are used is a contributing factor to this disparity. Large establishments in these areas, which have air-conditioning units, are drilling wells in order to obtain cooler water than that which can be supplied from overhead storage. Because of the fact that the wells are not metered, no records of the quantities of water used therefrom in public buildings, street-flushing, and system-leakage are available. Studies of surface-water supplies indicate that such usage constitutes approximately 20 per cent of the supplies. The average per capita use of ground water in six towns in the Neuse River Basin at the present time is 62.9 gallons daily, according to reports from water engineers in those towns. Assuming that the quantities of ground water used in public buildings, street-flushing, and system-leakage are the same as those of surface water, the total average per capita use of ground water in those towns is approximately 75.5 gallons daily.

A study of salt water intrusion in the lower reaches of the Neuse River, recently initiated under a cooperative agreement between the North Carolina Department of Conservation and Development and the Geological Survey, United States Department of the Interior, will provide valuable information regarding the infiltration of saline water into the ground-water aquifers in Carteret, Craven, and Pamlico Counties.

Total Use of Water for Domestic and Municipal Purposes - - Twelve domestic and municipal surface-water supplies in the Neuse River Basin provide for the needs of approximately 216,500 people, approximately 38 per cent of the basin population. Thirty-one domestic and municipal ground-water supplies furnish water to approximately 13.8 per cent of this population. The rural population, approximately 48.2 per cent of the total population, obtain their needs from provite ground-water supplies.

All farm homes, and all urban homes not using water from public water systems, are assumed to use ground water exclusively. Water consumption is probably close to 26 million gallons per day.

Estimated Increase of Total Use - - It is estimated that the population of the Neuse River Basin, which was approximately 548,000 in 1950, will amount to approximately 702,000 in 1970, and that the water used daily for domestic and municipal purposes in the basin, which was approximately 42 million gallons in 1954, will amount to approximately 75 million gallons in 1970.

Principal Crops in the Neuse River Basin -- The land in this basin is suitable for growing a great variety of agricultural products. The principal crops are corn, tobacco, grains, cotton, hay crops, vegetables, and peanuts, of which tobacco is the most important although corn is the largest from the standpoint of number of acres harvested. Fruits and vegetables are raised in the sandy uplands of the basin. Dairying is a growing industry in all sections of the basin.

Data regarding agricultural production are set forth in Tables 1 and 2 of this chapter. General information regarding farm population, number of farms, total land in farms, harvested cropland, idle cropland, and use of fertilizer is contained in Table 1. The use of land for pastures and various crops is indicated in Table 2. Table 1 pertains to the upstream counties; and information applicable to the downstream counties, and to the basin as a whole, is shown in Table 2.

Irrigation of Corn -- Corn is a warm-weather crop which requires a great amount of water throughout the growing season. With irrigation, corn can be grown, even in arid areas. The water needs of corn are greatest and most critical during the silking and tasseling periods. The proper amount of moisture at these times is so important to obtaining a good yield that, even in humid areas, many farmers have found that irrigation of corn is profitable.

Experiments in connection with the growing of corn indicate that irrigation has increased yields as much as 49 bushels per acre. In one experiment, a net return of $69.00 was obtained from an expenditure of $17.15 for irrigation.

In general, the irrigation of corn requires from one acre-foot to three acre-feet of water. Less than one acre-foot will be sufficient in humid areas where only one irrigation is required. Studies have shown that, when corn is making its most rapid growth, it will sometimes use as much as one-half of an inch of water per day for a period of several days.

As indicated in Table 2, 459,827 acres of corn were harvested in the Neuse River Basin in 1952. Permits to use water for irrigation, as of March 7, 1955, cover 1,166 acres of corn to be irrigated in the Neuse River Basin.

Irrigation of Tobacco -- The North Carolina Agricultural Experiment Station initiated in the spring of 1950 a program of research, pertaining to irrigation of flue-cured tobacco. The results of this research are as follows:

SUMMARY OF 1951 RESULTS

ITEM	IRRIGATED	UNIRRIGATED
Value per acre	$925.00	$587.50
Cost of irrigation	21.98	
Net increase from irrigation	315.52	
Increased cost of production	16.10	
Net gain	299.42	

TABLE I

1952 FARM CENSUS SUMMARY OF 1951 CROPS
NEUSE RIVER BASIN COUNTIES

	Person	Orange	Durham	Granville	Wake	Franklin	Nash	Johnston	Wilson	Wayne
Per cent of County in basin	34.2	52.16	72.71	24.01	84.10	11.60	21.74	97.93	81.58	94.49
Number of farms	973	1,063	1,297	801	5,230	478	1,273	7,930	3,510	4,644
Population, Jan. 1, 1952	5,431	6,221	7,212	4,324	29,411	2,557	7,091	39,612	18,922	23,257
Total land in farms, acres	82,621	111,203	100,103	69,523	362,050	33,914	69,413	456,251	178,939	290,647
Harvested Cropland, acres	19,548	21,505	18,890	16,460	101,875	10,108	29,229	199,098	88,947	140,143
Idle Cropland, Acres	4,459	9,357	8,128	3,257	21,309	2,026	1,126	6,738	1,694	3,922
Fertilizer used, tons	4,507	4,173	4,223	4,440	29,307	2,581	8,924	56,878	28,311	38,840
Tobacco harvested, acres	4,979	2,661	4,002	4,761	24,810	2,095	6,200	35,121	21,085	21,162
Corn harvested, acres	6,204	6,711	6,110	5,827	33,390	3,075	10,577	90,671	37,742	73,188
Cotton harvested Acres	0	91	122	133	8,141	1,752	4,938	33,020	12,628	18,514
Grain grown Acres	2412	5,945	3,200	982	14,728	1,093	4,647	17,561	9,504	15,769
Hay Crops harvested, acres	3,992	6,675	5,155	3,947	18,315	1,660	2,629	14,826	6,414	7,630
Pastures Acres	5,579	11,493	8,838	5,694	25,169	1,917	2,766	18,897	5,158	11,341
Vegetables grown, Acres	834	1,092	1,211	773	5,630	447	1,162	8,598	3,182	5,353

TABLE II

1952 FARM CENSUS SUMMARY OF 1951 CROPS
NEUSE RIVER BASIN COUNTIES

	Greene	Pitt	Lenoir	Jones	Craven	Pamlico	Beaufort	Carteret	Neuse River Basin
Per cent of County in basin	100	42.76	100	75.74	96.80	83.00	1.16	28.60	
Number of farms	2,945	2,552	3,781	1,215	2,270	655	39	176	40,832
Population, Jan. 1, 1952	15,283	13,188	19,517	5,314	11,873	3,732	181	1,150	214,276
Total land in farms, acres	157,188	156,528	222,728	110,952	183,262	68,301	3,522	16,178	2,673,323
Harvested Cropland, acres	76,716	70,456	99,036	32,318	52,063	21,849	1,249	3,443	1,002,833
Idle Cropland, acres	1,178	1,463	4,010	2,725	6,162	3,527	57	877	82,017
Fertilizer used, tons	24,162	20,441	31,020	8,226	14,372	4,856	269	1,467	285,357
Tobacco harvested, Acres	18,770	38,092	21,451	6,058	12,429	1,345	167	579	225,767
Corn harvested, Acres	42,379	32,991	57,635	18,600	25,972	7,204	469	1,082	459,827
Cotton harvested, Acres	6,982	5,381	4,719	532	1,060	426	30	67	98,536
Grain Grown, Acres	2,654	8,839	6,356	4,206	6,279	10,211	466	672	129,570
Hay Crops, harvested, acres	2,917	3,712	5,770	2,916	4,241	1,633	116	202	92,750
Pastures, Acres	3,637	4,049	8,947	3,636	5,786	3,219	94	536	126,766
Vegetables, grown, acres	1,813	2,307	3,480	963	2,105	1,808	56	1,040	41,854

SUMMARY OF 1952 RESULTS

ITEM	IRRIGATED	UNIRRIGATED
Value per acre	$826.00	$743.00
Cost of irrigation	24.68	
Net increase from irrigation	58.32	
Increased cost of production	3.25	
Net gain	55.07	

1953 IRRIGATION -- 10,560 PLANTS VS. 6,800 PLANTS PER ACRE

ITEM	10,560 plants	6,800 plants
Value per acre	$1,001.00	$826.00
Cost of irrigation	24.68	24.68
Net increase in plants	175.00	
Increased cost of production	102.50	
Net gain	72.50	

The tobacco was cultivated, topped, suckered, harvested, and cured in the conventional manner. In the 1951 season, 10 irrigations of approximately one inch each, totaling 8.2 inches, were applied. In the 1952 season, rainfall was greater, and 5 irrigations of 1.3 inches each were applied. It is apparent that, even with higher average rainfall, irrigation is needed in order to maintain suitable soil-moisture conditions. In the 1953 season, 8 irrigations of 1.1 inches each were applied. A heavy rain occurred subsequent to two of the eight irrigations without apparent damage to the crop. The results of the research show that irrigation increased the quality of the tobacco and the profit derived therefrom.

Irrigation of Pastures -- Livestock owners can contribute greatly to the food-production effort by improving the management of their pastures and establishing additional pastures. Fertile, well-managed pastures provide a livestock ration adequate in proteins, minerals, vitamins, and other food elements essential for production of milk, fattening of cattle, and growth of all livestock, including poultry. In addition to reducing requirements for food concentrates, more and better livestock can be produced if irrigated pasture is provided to supplement natural range. The labor cost of pasture herbage, harvested by the livestock, is less than that of other feeds. Many farmers are increasing their acreages of irrigated pasture and are improving the management of such pastures in order to increase production.

It has been found that, for good pastures, about 20 inches of water are required, amounting to about 543,000 gallons per acre per season.

Pastures in the Neuse River Basin have increased approximately 50 per cent during the past 10 years. As of March 7, 1955, permits to use water for irrigation covered 979 acres of pasture to be irrigated. As of January 1, 1952, pastures in the Neuse River Basin amounted to 126,766 acres.

Irrigation in General -- High stream flows in the Neuse River Basin generally occur when there is little need for irrigation water. The

lowest flows generally occur during the hot summer months when the need for such water is greatest. Storage of water in surface reservoirs during high flows, and diversion thereof when needed for irrigation, are essential for satisfactory crop protection and for the greatest practicable use of water supplies in many areas. Recognition of this need in North Carolina has resulted in the construction of approximately 13,000 farm ponds, a large percentage of which are used for irrigation purposes.

Double-cropping can be accomplished on many farms in the basin on which irrigation systems are installed, and the quality of irrigated crops is superior to that of unirrigated crops. Because of this improved quality and of the fact that crop production is more likely to be assured when irrigation is used, cannery representatives are interested in inducing growers to take advantage of irrigation possibilities.

As of March 7, 1955, 77 permits to use water for irrigation, covering 3,754 acres of land to be irrigated, had been issued.

Loans for Irrigation Systems -- Public Law 597, 83rd Congress, makes available to farmers a new type of credit to finance soil conservation measures and extends the water facility loan program to the entire nation. Previously, water facility loans which are used by farmers to develop irrigation systems and farmstead water supplies were limited to 17 western states. The law also makes it possible, for the first time, for the Government to insure conservation and water facility loans advanced by private lenders.

It is difficult to estimate the effect which this legislation may have on the agricultural progress in North Carolina. In addition to advancing conservation work, the credit made available through the legislation should materially assist in facilitating long-needed land-use adjustment and should aid in bringing about desirable uses of acres diverted from the production of surplus crops, as well as relieve the impact of drought conditions.

Much progress has been made in conserving the soil and water resources of the State. The job is far from finished. Lands are producing only a portion of their potential capacity, and soil resources are being used at a rate faster than they are being built up.

The soil, water, and forest resources are the foundation blocks in the structure of the State and National economy. How well these resources are protected and improved in the years ahead will have a direct bearing on the standard of living of citizens in the towns and cities as well as on the farms. Despite temporary surpluses of certain agricultural commodities at the present time, the demand upon agriculture will grow heavier in the years ahead.

A well planned program for resource conservation often comprises practices requiring considerable capital investment or temporary economy sacrifices. Public and private credit geared to the repayment potentials of conservation practices will materially aid on many farms. Public Law 597 will provide a part of the needed capital.

The fact that the law provides for the insuring of loans advanced by private lenders is one of its outstanding features. Not only will

this make it easier for private capital to assist farmers but it also will lessen the demands upon the Federal Treasury.

The loan services authorized by Public Law 597 will be made available through the Farmers Home Administration, an agency in the United States Department of Agriculture. This agency has either full-time or part-time offices, serving all counties in the State. The offices are located at the county seats, except in Ashe, Lee, Rockingham, and Wilkes Counties, and are staffed with County Supervisors experienced in the handling of a wide variety of credit services. A county committee of three leading citizens, at least two of whom are outstanding farmers, who have a proven knowledge of agricultural conditions and who are willing to make their services available for the benefit of their communities, review applications for loans, decide whether or not an applicant is eligible for a loan, and take other steps to adapt the program to local conditions. The committeemen are now performing the same services on other types of loans made by the Farmers Home Administration in each of the 100 counties in the State. They already possess the training and experience needed to do the job and add an all important element of local control.

Soil and Water Conservation loans will not duplicate or compete with other types of credit. They will supplement but will not substitute for private and cooperative credit. Applicants who need engineering services in the development of plans for irrigation systems, drainage, and other conservation measures to be carried out with loans will obtain these services from other agencies or private sources. In addition, loans will be made only for the types of soil and water conservation practices recommended by the Soil Conservation Service, the Extension Service, and other agricultural agencies.

To be eligible for a Soil and Water Conservation loan the applicant must be a farm owner or operator, be unable to finance the improvements with his own resources, and be unable to obtain the necessary credit from private or cooperative sources on terms and conditions that he reasonably can be expected to fulfill. He must have enough experience or training to indicate reasonable prospects of carrying on successful farming operations and must plan to improve a farm, on which the operator is engaged primarily in farming, on a scale at least equal to the size of operations conducted in the area by persons engaged primarily in farming.

Non-profit organizations such as incorporated water users associations, mutual water and drainage companies, and irrigation and drainage districts may be eligible for Soil and Water Conservation loans, provided they are unable to obtain adequate credit elsewhere, and further provided they are primarily engaged in extending to their members services directly related to soil conservation, water development, conservation, and use, or drainage of farm land.

Applicants must comply with federal, state, and local laws and regulations governing diverting, appropriating, and using water, installing facilities for draining land, and, where the applicant proposes to irrigate farm land, he must supply evidence to show that the supply of water will be adequate, and that his use of the water will not interfere with vested rights or existing established uses, and will not likely be contested by water users or owners. In case water is to be impounded, he must also furnish evidence that he has complied with local and state health laws and regulations.

Loans may be made to pay the cash cost of making improvements directly related to soil conservation, water development, conservation, and use, forestation, drainage of farm land, and related measures, including such improvements as the construction and repair of terraces, dikes, ponds and tanks, ditches and canals for irrigation and drainage, sodding, subsoiling, pasture improvement, brush removal, land leveling, basic application of lime and fertilizer, fencing, tree planting, well drilling, and the purchase of pump and other irrigation equipment. Loans may not be made for annually recurring costs that generally are considered as farm operating expenses.

Individuals and corporations engaged in farming may borrow up to $25,000. The ceiling on loans to non-profit incorporated associations is $250,000.

Loans are scheduled for repayment within the shortest time consistent with the borrower's ability to repay. In no case will the repayment period on loans to individuals exceed twenty years. Loans to associations will be repaid on the same basis as individual loans. In exceptional cases, they can be amortized over periods up to forty years. Each borrower will be required to refinance the unpaid balance of the loan when able to obtain a loan at reasonable rates and terms from other sources.

Loans will be secured by the best liens obtainable on chattels, real estate, or both, to the extent necessary to protect adequately the interest of the Government.

Soil and Water Conservation loans may be made from funds furnished by private lenders such as banks, insurance companies, or any organization or individual wanting to invest in Government insured notes and at the same time cooperate in a program that helps develop the agricultural interests in the community. Loans may be made from funds appropriated by the Congress only when insured funds by private lenders are not available.

For insured loans, the interest rate to the lender is $3\frac{1}{2}$ per cent per year on the unpaid principal. In addition, the borrower will pay an annual mortgage insurance charge of one per cent per year on the unpaid principal. The interest rate is $4\frac{1}{2}$ per cent per year for direct loans made out of appropriated funds.

In case of either direct or insured loans, the Farmers Home Administration makes the loans, collects the payments, and services the security.

Applications for all loans, insured or direct, may be made at the local county office of the Farmers Home Administration serving the county in which the farm to be improved is located. Applications from veterans receive preference in processing. All applications for Soil and Water Conservation loans are reviewed by the local three-member FHA County Committee, and no loan may be made unless the County Committee certifies that the applicant is eligible for such assistance. Where the loan is to be secured by a lien on the real estate to be improved, the County Committee must also certify as to the normal market value of the property.

Technical assistance for planning and installing the improvements will be obtained by the applicant from the Soil Conservation Service, Extension Service, private individuals or firms. Technical assistance from the

Farmers Home Administration will be limited to assisting applicants in determining that the engineering is feasible, that the cost estimates and plans are complete and reasonable, that the proposed improvements are economically sound and are in accordance with practices recommended by the Extension Service and the Soil Conservation Service, that loan funds are used for authorized purposes, and that the work meets approved standards.

Agricultural Use -- There are many farm ponds in the Neuse River Basin, created by damming small streams or by devising hillside catchment basins to trap rainfall and surface runoff. These ponds are used for fishing, stock-watering, and for irrigating farm crops. Prior to 1954, there was but little surface water used for irrigation. During the drought period in the summer and fall of 1954, however, the practice of irrigation greatly increased. No estimate of the total volume of surface water used for agriculture is available. The amount is probably very insignificant in relation to the total supply in the basin. Irrigation during dry seasons may be expected to increase greatly in coming years.

There has been a significant increase in the use of ground water for irrigation in recent years, although no reasonable estimate of the volume used can be made. In addition to that furnished by drilled wells, much irrigational water in the eastern half of the basin comes from large excavations that act as large dug wells. The expected increase in use of ground water for irrigation is not likely to cause a large-scale lowering of ground-water levels in the foreseeable future.

Nature of Industrial Production - - The principal industries in the Neuse River Basin are engaged in the manufacture of tobacco, textile, and lumber products. The greater part of the industrial development is located in the Piedmont area, principally in the City of Durham, renowned for its tobacco and textile products. Lumbering is carried on throughout the basin. It is only in the Coastal Plain, however, that this industry has commercial importance. The principal merchantable timbers are long and short leaf pine, gum, juniper and cypress. The commercial importance of minerals in the basin is small. Nine commercial quarries and one marl pit are operated in the basin. The following table indicates the distribution of industries throughout the basin.

County	Industries
Carteret	Fisheries -- lumber
Craven	Ceramics -- lumber -- marl quarries
Durham	Textiles -- tobacco -- stone & shale quarries
Franklin	Textiles -- lumber
Granville	Lumber -- pyrophyllite quarry
Greene	Textiles -- lumber -- heating apparatus
Johnston	Textiles -- lumber -- products from fabrics
Lenoir	Textiles -- lumber -- shirt and tobacco factories
Nash	Lumber
Orange	Textiles -- lumber -- pyrophyllite quarry
Pamlico	Lumber -- food products
Pitt	Lumber
Wake	Textiles -- lumber -- stone quarries
Wayne	Textiles -- lumber -- sand and gravel
Wilson	Textiles -- tobacco -- lumber -- stone quarry

Use of Water by Industries - - Most of the water for industrial use is obtained from streams and is supplied to industries by the cities and towns in which the industries are located. Estimates of the quantities used are not available in most cases. The City of Raleigh furnishes approximately 1.5 million gallons per day to the Meter Division, Western Electric Company, and to the American Woolen Company. The City of Durham supplies a large amount of water to the industries located therein. The Dupont Company is operating a large plant in Lenoir Company and is using approximately two million gallons per day from five wells. This supply constitutes the largest industrial use of water in the basin.

Private Industrial Supplies - - Water occurring as stream flow is used at various points in the basin for water power to operate grist mills and electric power plants, for cooling water in steam-electric plants and other plants using steam power, and for processing textile products. Some of these uses of stream flow do not require diversion, and, of the water withdrawn from streams for the other uses, the greater part is returned to the stream from which it is withdrawn. Reliable estimates of the volumes of stream flow withdrawn for industrial use are not available; the total

volume is probably in the order of magnitude of 150 million gallons per day.

Textile plants are the greatest users of water in the Neuse River Basin. Most of these plants use ground water for drinking and some other purposes. Many of them use ground water for all or most of their operations. Many food processing plants and several smaller industries use wells as a source of water supply. Industrial use of ground water is estimated to be about 30 million gallons per day.

Significance of Quality of Water - - An adequate water supply is a determining factor in the selection of an industrial site. Sharing importance with quantity is a knowledge of the chemical quality, degree of pollution, and a seasonal estimate of suspended sediment carried by the stream. Water is commonly thought of as being fresh or salty. Fresh water generally includes rain, lakes, rivers, and underground waters that are suitable for drinking and ohter domestic uses and for industrial and agricultural purposes. Salt water includes the oceans and bodies of some surface and underground waters that contain so much dissolved minerals that they are not satisfactory for human consumption or for almost any other use.

Chemical analyses of water for municipal or industrial purposes are necessary to determine whether the water is suitable for specific purposes, and, if not, to determine the type and cost of the treatment needed to make it satisfactory. The analyses aid in determining the suitability of the water for steam, processing industries, laundering, or other purposes. Complete analyses can also be used to determine the cost of softening water, its tendency to produce scale in steam boilers and domestic hot-water tanks, and its corrosive potential on plumbing.

The chemical quality of the water used by various industries is so different that it is impossible to establish specifications to fit all uses. Water that may be suitable for one industrial process may be entirely unsuitable for another. In general, however, most industries require water free from color, turbidity, and suspended matter, and low in total mineral content, hardness, manganese, and iron. Water temperature is also an important factor in determining the value of water for industrial use. The requirements of chemical quality of water for industrial processes are given in Table I of this chapter.

Unlike waters used by industry, chemical specifications have been generally accepted for waters used domestically. These chemical specifications are independent of any sanitary specifications established for protection of the public health. In 1946 the United States Public Health Service established chemical specifications for drinking water used on interstate carriers as follows:

Iron and manganese together:	Not to exceed	0.3	ppm
Magnesium:	Not to exceed	125	ppm
Chloride:	Not to exceed	250	ppm
Sulfate:	Not to exceed	250	ppm
Fluoride:	Not to exceed	1.5	ppm
Lead:	Not to exceed	0.1	ppm
Color:	Less than	20	units

Waters containing less than 500 ppm of dissolved solids generally are satisfactory for most domestic and industrial uses. However, an excessive amount of iron or hardness may cause difficulty in some uses. Waters with more than 1,000 ppm of dissolved solids are likely to include certain constituents that make them unsuitable for domestic or industrial uses.

TABLE I - WATER QUALITY TOLERANCES FOR INDUSTRIAL APPLICATIONS 1/
(part per million)

Industry	Turbidity	Color	Fe	Mn	Fe + Mn	Hardness	Alkalinity	pH	Total Solids	General 2/
Air Conditioning 3/	- -	- -	0.5	0.5	0.5	- -	- -	- -	- -	A,B
Baking	10	10	0.2	0.2	0.2	4/	- -	- -	- -	C
Boiler Feed:										
0-150 psi.	20	80	- -	- -	- -	75	- -	8.0+	3000-1000	- -
150-250 psi.	10	40	- -	- -	- -	40	- -	8.5+	2500-500	- -
250 psi. and up	5	5	- -	- -	- -	8	- -	9.0+	1500-100	- -
Canning:										
Legumes	10	- -	0.2	0.2	0.2	25-75	- -	- -	- -	C
General	10	- -	0.2	0.2	0.2	- -	- -	- -	- -	C
Carbonated Beverages 5/	2	10	0.2	0.2	0.3	250	50	- -	850	C
Confectionary	- -	- -	0.2	0.2	0.2	- -	- -	6/	100	- -
Cooling 7/	50	- -	0.5	0.5	0.5	50	- -	- -	- -	A,B
Ice (Raw Water) 8/	1-5	5	0.2	0.2	0.2	- -	30-50	- -	300	C
Laundering	- -	- -	0.2	0.2	0.2	50	- -	- -	- -	- -
Plastics, Clear, Uncolored	2	2	0.02	0.02	0.02	- -	- -	- -	200	- -
Paper and Pulp: 9/										
Groundwood	50	20	1.0	0.5	1.0	180	- -	- -	- -	A
Kraft Pulp	25	15	0.2	0.1	0.2	100	- -	- -	300	- -
Soda and Sulfite	15	10	0.1	0.05	0.1	100	- -	- -	200	- -
Light Paper, HL-Grade	5	5	0.1	0.05	0.1	50	- -	- -	200	B
Rayon (Viscose) Pulp:										
Production	5	5	0.05	0.03	0.05	8	50	- -	100	10/
Manufacture	0.3	- -	0.0	0.0	0.0	55	- -	7.8-8.3	- -	- -
Tanning 11/	20	10-100	0.2	0.2	0.2	50-135	135	8.0	- -	- -
Textiles:										
General	5	20	0.25	0.25	- -	20	- -	- -	- -	- -
Dyeing 12/	5	5-20	0.25	0.25	0.25	20	- -	- -	- -	- -
Wood Scouring 13/	- -	70	1.0	1.0	1.0	20	- -	- -	- -	- -
Cotton Bandage 13/	5	5	0.2	0.2	0.2	20	- -	- -	- -	- -

TABLE I - WATER QUALITY TOLERANCES FOR INDUSTRIAL APPLICATIONS - CONTINUED

1/ American Water Works Association, Water Quality and Treatment, Table 3-4, p. 67, 1950

2/ A -- No corrosiveness; B -- No slime formation; C -- Conformance to federal drinking water standards necessary; D - - NaCl, 275 ppm.

3/ Water with algae and hydrogen sulfide odors are most unsuitable for air conditioning.

4/ Some hardness desirable.

5/ Clear, odorless, sterile water for syrup and carbonization. Water consistent in character. Most high quality filtered municipal water not satisfactory for beverages.

6/ Hard candy requires pH of 7.0 or greater, as low value favors inversion of sucrose, causing sticky product.

7/ Control of corrosiveness is necessary as is also control of organisms, such as sulfur and iron bacteria, which tend to form slimes.

8/ $Ca(HCO_3)_2$ particularly troublesome. $Mg(HCO_3)_2$ tends to greenish color. CO_2 assists to prevent cracking. Sulfates and chlorides of Ca, Mg, Na should each be less than 300 ppm (white butts).

9/ Uniformity of composition and temperature desirable. Iron objectionable since cellulose absorbs iron from dilute solutions. Manganese very objectionable, clogs pipelines and is oxidized to permanganates by chlorine, causing reddish color.

10/ Al_2O_3 less than 8 ppm, SiO_2 less than 25 ppm, Cu less than 5 ppm.

11/ Excessive iron, manganese or turbidity creates spots and discoloration in tanning of hides and leather goods.

12/ Constant composition; residual alumina 0.5 ppm.

13/ Calcium, magnesium, iron, manganese, suspended matter and soluble organic matter may be objectionable.

Hardness in water, in respect to both domestic and industrial use, is of great importance. In domestic use, hardness is recognized by the difficulty in obtaining a lather without an excessive consumption of soap; the insoluble, sticky curd that results with the use of soap; and the scale formed in vessels in which the water is boiled. Industry gives great attention to hardness in water supplies because of its effects in the various processes of manufacturing and on the manufactured product, and because of the scale deposited in hot-water pipes, hot-water heaters, and steam boilers resulting in economic loss through loss of heat transfer, increased fuel consumption, and breakdown of equipment. Calcium and magnesium are the principal causes of hardness. Other constituents, such as iron, manganese, aluminum, barium, strontium, and free acid, also cause hardness but generally they are not present in sufficient quantities to have an appreciable effect. Water with a hardness of less than 60 ppm is usually rated as soft and suitable for most purposes. Waters with hardness ranging between 60 and 120 ppm may be considered moderately hard, but do not seriously interfere with the use of water except in high pressure steam boilers and in some industrial processes. Waters with hardness ranging from 121 to 200 ppm are considered hard, and, in the upper ranges, launderies and industries may profitably soften the supply. Waters with hardness greater than 200 ppm usually require some softening before being used for most purposes.

Iron and manganese in excess of 0.3 ppm are objectionable for a number of reasons. Excessive amounts of iron and manganese cause reddish-brown stains on white porcelain or enamel ware, on fixtures, and on clothing or other fabrics. These two constituents in excessive amounts, interfere with dyeing, tanning, paper manufacturing, and the manufacture of photographic film.

Color, in water analysis, refers to the appearance of water that is free of suspended material. Generally waters are colored by organic matter leached from plants, tree roots, and organic components of soils. Highly colored waters may cause foaming in boilers, may hinder iron removal and hot phosphate softening, and can stain processed products. Also, color is objectionable in public water supplies from an esthetic point of view.

The dissolved solids consist mainly of the minerals in solution. The amounts and character of the dissolved solids present in a natural water depend on the solubility and types of rocks with which the water has been in contact. High concentrations of dissolved solids may be objectionable because of interference of manufacturing certain products and as a cause of foaming in boilers.

Public Water-Supply Systems -- The Neuse River Basin is served by 43 public water systems, 9 using surface water and 34 using ground water. Location of the systems, giving the source of supply and the dissolved-solids content and hardness of the water, may be found in the report in preparation by the United States Geological Survey, referred to in the bibliography herein. A summary of chemical analyses of raw and treated waters for the water supply systems in the basin is given in Table II of this chapter. Additional pertinent data related to the systems are set forth below:

Apex, Wake County

Ownership: Municipal. Population served: 1,084. Source: Reservoir on two unnamed streams forming a 35 acre lake. Treatment: Coagulation with alum, chlorination, rapid sand filtration, final adjustment of pH with lime. Rated capacity of filtration plant: 324,000 gpd. Raw water storage: None. Finished water storage: 100,000 gallons elevated tank. Location of filtration

TABLE II - CHEMICAL ANALYSES OF WATER FROM PUBLIC WATER SUPPLIES IN THE NEUSE RIVER BASIN

(Analyses, in parts per million, by U. S. Geological Survey)

Location	Date of collection	Type	Depth of well	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$		Specific conductance (Micromhos at 25°C)	pH	Color
																		Calcium, Magnesium	Noncarbonate			
Apex	4/3/52	Raw	...	5.5	0.06	0.00	3.2	1.3	5.0		9	0	6.5	6.5	0.1	0.8	40	13	6	52.4	6.7	25
Do.....	..Do....	Finished	...	3.7	.03	.08	17	1.4	5.2		13	0	32	10	.2	1.1	84	48	38	140	6.7	2
Ayden	2/9/48	Raw	155	19	.68	.07	42	2.9	9.2		155	0	4.5	3.4	.1	.0	157	117	0	.....	7.6	12
Do.....	9/21/51	Raw	450	11	3.3	.00	12	1.7	11		44	0	11	9.4	.1	.5	81	37	1	142	6.3	3
Bailey	7/22/48	Raw	250	4.9	6.6	.28	5.6	3.8	4.3		39	0	2.4	2.9	.1	.0	43	30	0	.....	6.9	6
Do.....	3/4/54	Finished	155	24	4.0	.00	4.1	4.2	14		39	0	11	8.8	...	1.4	114	28	0	134	6.5	4
Beaufort	1/4/55	Finished	348	36	.09	.00	69	26	24	9.3	383	0	2.6	13	.3	1.3	369	278	0	588	7.2	12
Benson	5/16/47	Raw	550	12	.09	.00	17	6.9	54		129	0	5.9	54	.2	.2	214	71	0	.....	7.8	3
Do.....	4/23/54	Raw	800	11	.00	.00	13	5.6	49		130	0	4.4	36	.1	.0	186	56	0	334	7.9	3
Cary	4/3/52	Raw	200	43	.33	.14	12	3.1	9.9		68	0	3.6	3.2	.1	.1	108	43	0	128	6.7	2
Do.....	6/2/53	Raw	400	37	1.1	.04	74	11	26		117	0	179	3.4	.1	.0	417	230	134	570	7.3	3
Do.....	9/18/54	Raw	250	41	1.9	.00	14	5.6	9.7	1.7	87	0	8.6	3.5	.0	.2	127	57	0	172	6.6	10
Do.....	11/18/54	Raw	500	47	1.8	.00	22	5.1	15	1.6	124	0	6.7	2.5	.1	.1	160	77	0	221	7.2	15
Cherry Point	1/5/53	Raw	250	31	2.6	.00	85	2.3	8.1		275	0	1.0	8.5	.3	.0	283	222	0	447	7.1	18
Do.....	..Do....	Finished	...	24	.12	.00	15	2.6	18		42	8	17	14	.4	.0	126	48	0	180	8.6	7
Clayton	5/20/48	Raw	250	27	.02	.00	20	2.0	23		72	0	11	20	.0	12	158	58	0	.....	6.6	2
Do.....	4/23/54	Raw	125	30	1.1	.00	12	4.5	12		63	0	7.7	9.0	.1	2.6	113	48	0	157	6.6	2
Do.....	..Do....	Raw	...	29	.18	.00	13	3.4	13		66	0	8.3	8.0	.2	1.3	114	46	0	157	6.6	2
Cove City	7/6/49	Raw	280	9.7	.15	.00	4.7	4.3	140		365	13	1.4	7.0	1.0	.2	369	29	0	602	8.3	9
Creedmoor	1/21/54	Raw	...	7.0	.11	.00	3.7	.9	5.2		7	0	12	3.8	.0	.8	55	13	7	65.1	6.0	36
Do.....	..Do....	Finished	...	4.3	.08	.00	29	5.7	6.6		18	4	76	6.2	.0	1.2	146	96	74	233	9.2	5
Durham	1/31/55	Raw	...	8.7	.08	.00	5.0	1.2	5.6	1.9	25	0	7.3	3.8	.0	.5	53	17	0	60.6	6.8	22
Do.....	..Do....	Finished	...	6.8	.02	.00	18	1.7	3.5	1.6	22	4	27	9.0	.1	1.0	92	51	27	141	9.0	7
Farmville	11/11/47	Raw	500	20	.14	.00	1.0	1.6	136		226	0	25	65	.7	.5	369	9	0	.....	7.8	15
Do.....	..Do....	Raw	500	16	.22	.00	8.8	5.1	79		220	0	8.8	16	.5	.6	244	43	0	.....	8.0	3
Fountain	1/12/48	Raw	194	20	.19	.00	36	6.8	57		137	0	7.1	86	.2	.4	285	118	6	.....	7.6	0
Fremont	4/26/48	Raw	596	17	.26	.00	72	23	189		191	0	140	271	.3	.9	853	274	118	.....	7.6	3
Do.....	1/3/55	Raw	280	15	.07	.00	49	17	17	18	199	0	28	41	.0	1.5	280	191	28	490	7.7	5
Gerner	1/21/54	Raw	...	33	.13	.00	9.7	5.4	9.8		72	0	4.2	2.5	.2	.4	98	46	0	149	6.7	4
Do.....	..Do....	Raw	175	33	.09	.00	6.2	2.9	6.0		40	0	2.4	3.2	.1	.5	81	27	0	79.2	6.6	4
Do.....	..Do....	Raw	150	35	.04	.00	4.8	2.0	5.5		31	0	1.5	3.2	.1	.6	76	20	0	76.9	6.3	1
Goldsboro	8/12/50	Raw	...	13	.06	.00	2.8	1.2	5.1		16	0	3.5	4.2	.0	.5	50	12	0	51.2	6.6	17
Do.....	..Do....	Finished	...	14	.06	.00	14	1.3	5.8		25	0	21	7.2	.0	.4	86	40	20	120	6.9	3
Grifton	6/14/54	Raw	135	20	.31	.00	35	4.9	24	6.5	189	0	3.5	5.5	.3	.1	193	108	0	315	8.1	3
Hillsboro	1/31/55	Raw	...	15	.07	.00	4.8	1.5	4.7	.7	22	0	5.8	3.5	.0	.3	52	18	0	69.7	7.0	10
Do.....	..Do....	Finished	....	14	.12	.00	12	1.5	4.2	.4	19	7	14	4.2	.0	.0	75	35	8	102	9.2	10
Hookerton	1/4/55	Raw	380	13	.12	.00	.2	.2	84	7.0	181	0	15	30	.0	.8	247	2	0	408	7.9	12
Kenly	11/4/47	Raw	96	12	.49	.12	8.7	13	33		20	0	6.4	72	.1	27	194	75	59	.....	5.9	6
Do.....	..Do....	Raw	110	15	.19	.00	4.6	6.0	6.8		18	0	3.2	14	.1	16	82	36	21	.....	6.2	3
Do.....	5/27/54	Raw	200	22	.66	.00	9.8	2.8	13		58	0	4.6	6.5	.1	2.4	91	36	0	134	6.9	4
Kinston	2/19/51	Raw	375	13	.17	.00	7.6	2.7	40		127	0	3.1	6.0	.2	.3	138	30	0	227	7.7	3
Do.....	..Do....	Raw	550	9.8	.73	.00	6.4	2.9	47		145	0	1.4	6.0	.3	.1	151	28	0	252	7.7	12
Do.....	1/3/55	Raw	435	11	.22	.00	9.6	6.6	30	17	156	0	3.5	2.2	.1	1.0	153	51	0	254	8.0	8
Knightdale	5/9/51	Raw	92	48	.35	.00	9.0	3.0	7.3		48	0	1.1	3.9	.1	5.5	105	35	0	110	6.6	2
Do.....	6/12/51	Raw	195	35	.13	.00	2.8	.7	8.8		29	0	1.1	2.6	.1	.4	68	10	0	58.0	6.0	3
LeGrenge	5/15/47	Raw	238	24	1.7	.00	4.6	2.7	40		111	0	3.3	11	.2	.2	146	23	0	.....	7.4	37
Do.....	1/3/55	Raw	321	26	.31	.00	2.4	1.2	32	6.4	89	0	5.6	7.8	.1	1.2	127	11	0	173	7.3	10
Lucama	5/15/47	Finished	190	42	.88	.00	27	3.7	6.5		100	0	4.9	6.0	.4	.1	148	83	1	.....	7.7	18
Middlesex	3/4/54	Finished	86	35	.10	.00	7.6	2.9	6.8		45	0	1.5	4.8	.1	.4	81	31	0	96.3	6.4	3
Morehead City	1/4/55	Finished	230	40	.17	.00	96.	5.4	8.8	4.8	320	0	1.6	10	.0	1.3	337	262	0	508	7.2	17
Do.....	..Do....	Finished	...	41	.10	.00	84	11	9.9	7.0	321	0	1.4	9.5	.0	1.3	336	256	0	513	7.2	13
Mount Olive	12/2/46	Raw	170	32	1.4	.08	7.9	1.0	9.5		39	0	5.9	3.8	.4	.0	83	24	0	.....	6.0	12
Do.....	8/21/53	Raw	282	32	.74	.00	7.0	1.6	5.1		32	0	2.9	4.0	.1	.1	73	24	0	76.3	6.2	4
New Bern	11/19/52	Raw	....	15	1.4	.00	79	1.8	14		214	0	15	31	.0	.0	279	204	29	442	7.1	3
Do.....	6/10/54	Raw	126	22	3.9	.00	76	2.4	2.9		239	0	.2	6.5	.1	.3	237	199	4	388	7.3	5
Do.....	11/19/52	Finished	...	15	.14	.00	23	.5	74		216	0	13	21	.0	.0	253	59	0	423	7.5	6
Pikeville	10/19/53	Raw	87	13	1.4	.00	3.4	1.5	3.6		12	0	6.7	3.8	.1	.2	41	15	5	44.5	5.6	6
Pink Hill	2/1/55	Raw	220	12	.26	.00	48	.7	2.9	1.0	150	0	1.5	3.2	.1	.0	151	123	0	256	7.5	0
Princston	1/5/48	Raw	141	32	.21	.08	24	4.5	20		123	0	13	4.6	.1	.0	159	78	0	.....	7.8	13
Do.....	6/7/54	Raw	236	33	.55	.00	23	4.7	8.6		97	0	11	2.5	.2	.4	139	77	0	189	7.6	3
Raleigh	2/16/55	Raw	...	2.4	.01	.00	3.6	.7	4.3	1.2	17	0	5.6	3.2	.0	.0	40	12	0	48.1	6.9	23
Do.....	..Do....	Raw	...	11	.03	.00	3.2	1.5	4.3	2.6	17	0	5.8	3.2	.1	.0	50	14	0	50.8	6.7	33
Do.....	..Do....	Finished	...	7.1	.02	.00	11	1.4	4.9	1.4	20	0	23	5.5	.2	.1	69	33	17	100	7.5	3
Selma	11/54	Raw	270	27	3.8	.60	19	5.8	12	1.5	87	0	17	8.8	.1	.3	142	71	0	209	6.8	2
Do.....	9/23/54	Raw	292	28	1.1	.40	18	3.2	12	1.2	65	0	27	3.0	.1	.9	130	59	5	178	6.8	5
Do.....	2/25/55	Finished	...	28	.39	.00	18	4.4	29	1.8	112	0	22	7.5	.0	.1	169	64	0	243	8.1	7
Smithfield	4/24/54	Raw	...	16	.08	.00	4.9	1.9	7.4		24	0	5.1	6.5	.1	2.3	59	20	0	75.6	6.6	19
Do.....	..Do....	Finished	...	13	.03	.00	17	2.6	17		46	0	40	7.0	.1	1.5	125	53	15	194	7.8	3
Snow Hill	5/26/47	Raw	260	11	.09	.00	4.4	2.8	91		204	0	11	28	.4	.3	255	22	0	.....	7.9	3
Stentonsburg	9/12/53	Raw	160	24	.38	.01	20	6.8	40		171	0	9.0	11	.2	.2	204	78	0	325	7.2	4
Do.....	..Do....	Raw	40	20	.90	.01	18	6.9	48		178	0	11	13	.2	.5	211	73	0	356	7.4	3
Weke Forest	1/21/54	Raw	...	9.4	.14	.00	2.2	.5	6.6		10	0	6.8	4.2	.0	.8	48	8	0	49.0	6.3	25
Do.....	..Do....	Finished	...	12	.10	.00	17	.8	6.7		10	0	44	4.0	.0	.8	92	46	38	136	6.3	5
Waletonburg	7/28/49	Raw	210	26	.47	.04	8.7	5.2	41		142	0	5.5	6.4	.3	.4	164	43	0	248	7.0	3
Wendell	2/17/48	Raw	602	38	.02	.00	3.6	.7	8.5		29	0	.7	2.8	.1	2.0	75	12	0	.....	6.2	5
Wilson	6/14/50	Raw	...	7.6	.21	.00	2.3	1.1	5.6		15	0	2.9	4.9	.0	.3	40	10	0	48.1	6.7	28
Do.....	..Do....	Finished	...	8.3	.06	.00	14	1.4	13		34	0	30	6.5	.1	.8	92	41	13	155	7.9	4
Winterville	7/11/49	Raw	157	31	1.5	.07	69	2.9	8.2		227	0	2.4	9.2	.1	.1	237	184	0	371	7.2	2
Do.....	..Do....	Raw	304	28	2.3	.00	73	1.7	8.7		213	0	8.9	17	.1	.2	249	189	15	387	7.3	2
Youngsville	2/17/54	Finished	510	28	.12	.00	18	6.6	11		95	0	12	3.2	.1	.1	131	72	0	187	7.0	4
Zebulon	1/21/54	Raw	...	11	.11	.00	2.4	.3	6.9		11	0	7.3	3.5	.1	.6	45	7	0	45.5	6.1	26
Do.....	..Do....	Raw	250	28	.15	.00	5.7	1.3	6.8		31	0	2.9	3.5	.1	.8	77	20	0	79.3	6.0	4
Do.....	..Do....	Finished	...	9.5	.15	.00	2.9	.6	12		0	0	29	4.2	.1	.6	62	10	10	98.1	4.5	7

plant: 3 miles northeast of Apex. It was necessary to supplement the normal water source with water from nearby lakes in 1954.

Ayden, Pitt County

Ownership: Municipal. Population served: 2,282. Source: 4 wells, (Nos. 1-4) 155, 155, 450, and 505 feet deep. The yield is reported to be 150, 250, 350, and 500 gpm. Well number 1 pumped into 100,000 gallon reservoir and then into elevated tank for distribution. Wells 2-4 are pumped directly into mains for distribution. Treatment: None. Ground storage: 100,000 gallon reservoir. Elevated storage: 60,000 gallon elevated tank.

Bailey, Nash County

Ownership: Municipal. Population served: 808. Source: 3 wells (1, 3, and 4) 250, 250, and 155 feet deep. The yield is reported to be 30, 80, and 80 gpm. Treatment: Wells numbers 1 and 3 no treatment. Well number 4 calgon and chlorination. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Beaufort, Carteret County

Ownership: Carolina Water Company. Population served: 4,390. Source: 3 wells (1, 2, and 3) 300, 400, and 348 feet deep. Well number 3 is reported to yield 400 gpm. Wells are located near the elevated tank and water is pumped directly into the mains and the elevated tank. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Benson, Johnston County

Ownership: Municipal. Population served: 2,220. Source: 3 wells (1, 2, and 3) 550, 717, and 800 feet deep. The yield is reported to be 200, 140, and 15 gpm. Treatment: None. Ground storage: 100,000 gallon reservoir. Elevated storage: 100,000 gallon elevated tank.

Cherry Point, Craven County

Ownership: U. S. Government. No information available as to population served. Source: Wells.

Clayton, Johnston County

Ownership: Municipal. Population served: 2,500. Source: 9 wells (Nos. 1-9) 185, 225, 225, 250, 210, 485, 225, 185, and 250 feet deep. The total yield of all wells is reported to be 341 gpm. Wells 1, 2, and 6 are pumped into ground reservoir and then into system. All other wells are pumped into distribution system. Treatment: None. Ground storage: 100,000 gallon reservoir. Elevated storage: 100,000 gallon elevated tank.

Cary, Wake County

Ownership: Municipal. Population served: 1,768. Source: 11 wells (Nos. 1-3 and 5-12) 320, 220, 320, 250, 200, 405, 300, 400, 300, 402, and 500 feet deep. The total yield of all wells is reported to be 532 gpm. All wells are pumped into distribution system at point of well location. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Cove City, Craven County

Ownership: Wells - Oates Lumber Company. Population served: 465. Source: 1 well 280 feet deep. Treatment: None. Ground storage: None. Elevated storage: None.

Creedmoor, Granville County

Ownership: Municipal. Population served: 2,075. Source: Ledge Creek impounded in 120,000,000 gallon lake. Treatment: Coagulation with alum, carbon, lime, rapid sand filtration, adjustment of pH with lime. Rated capacity of filtration plant: 140,000 gpd. Ground storage: 52,000 gallon clear well. Elevated storage: 68,000 gallon elevated tank. Location of filtration plant: 1 mile west of Creedmoor on Camp Butner Road.

Durham, Durham County

Ownership: Municipal. Population served: about 79,000. Source: Flat River impounded in Lake Michie, about 15 miles northwest of the City. Treatment: Partial aeration, breakpoint chlorination, coagulation with alum and lime, sedimentation, rapid sand filtration, and final adjustment of pH with lime. Activated carbon used occasionally for taste and odor control. Rated capacity of treatment plant: 15,560,000 gpd. Raw water storage: impounding reservoir, 4,500,000,000 gallons. Finished water storage: 5 clear wells, 4,500,000 gallons; 1 elevated tank, 1,500,000 gallons: 1 elevated reservoir, 3,000,000 gallons. Quantity of water used during 1954: 3176.6 million gallons. Maximum daily rate: 12.12 million gpd. Minimum daily rate: 5.87 million gpd.

Farmville, Pitt County

Ownership: Municipal. Population served: 3,535. Source: 3 wells (3, 4, and 5) 500, 300, and 500 feet deep. The yield is reported to be 350 150, and 500 gpm. Treatment: None. Ground storage: 100,000 gallon reservoir. Elevated storage: 300,000 gallon elevated tank.

Fountain, Pitt County

Ownership: Municipal. Population served: 525. Source: 1 well 194 feet deep. The yield is reported to be 60 gpm. Treatment: None. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Fremont, Wayne County

Ownership: Municipal. Population served: 1,395. Source: 2 wells (1 and 2) 596 and 252 feet deep. The yield is reported to be 94 and 90 gpm. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Garner, Wake County

Ownership: Municipal. Population served: 710. Source: 6 wells (Nos. 1-6) 135 to 175 feet deep. Treatment: None. Ground storage: None. Elevated storage: a 50,000 gallon elevated tank to be installed prior to June 30, 1955.

Goldsboro, Wayne County

Ownership: Municipal. Population served: about 25,000. Source: Little River. Treatment: Prechlorination, coagulation with alum and lime, sedimentation, rapid sand filtration, postchlorination, and final adjustment of pH with lime. Rated capacity of treatment plant: 3,000,000 gpd. Raw water storage: None. Finished water storage: 500,000 gallon clear well; 1,000,000 gallon elevated tank. Location of treatment plant: 2 miles northwest of Goldsboro on the south bank of Little River.

Grifton, Pitt County

Ownership: Municipal. Population served: 1,700. Source: 3 wells (1, 2, and 3) each well 135 feet deep. The total yield is reported to be 541 gpm. Treatment: None. Ground storage: None. Elevated storage: 60,000 gallon elevated tank.

Hillsboro, Orange County

Ownership: Municipal. Population served: 2,360. Source: Eno River. Treatment: Coagulation with alum, rapid sand filtration, postchlorination, and final adjustment of pH with lime. Rated capacity of filtration plant: 500,000 gpd. Raw-water storage: None. Finished water storage: 50,000 gallon clear water well; 200,000 gallon standpipe; and 20,000 gallon elevated tank. Location of filtration plant: 2 miles west of Hillsboro. Plans have been made to build a 24,000,000 gallon impounding reservoir on Eno River.

Hookerton, Greene County

Ownership: Municipal. Population served: 350. Source: 1 well 380 feet deep. The yield is reported to be 120 gpm. Treatment: None. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Kenly, Johnston County

Ownership: Municipal. Population served: 1,520. Source: 3 wells (1, 2, and 3) 96, 110, and 200 feet deep. The yield is reported to be 90, 70, and 200 gpm. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Kinston, Lenoir County

Ownership: Municipal. Population served: 27,500. Source: 5 wells (Nos. 1-5) 361, 369, 365, 552, and 435 feet deep; 3 artesian wells (Hillcrest group); 350 to 390 feet deep. The yield of the 5 wells is reported to be 900, 690, 460, 900, and 980 gpm. The flow of the artesion group is 150 gpm. Treatment: The water from the 5 wells is chlorinated before entering the distribution system. Water from the Hillcrest wells flows into a reservoir and is then pumped into the distribution system. Ground storage: 2 reservoirs, 1,000,000 and 250,000 gallons. Elevated storage: 500,000 gallon elevated tank.

Knightdale, Wake County

Ownership: Municipal. Population served: 620. Source: 2 wells (1 and 2) 195 and 95 feet deep. The yield of the 2 wells is reported to be 82 and 22 gpm. Treatment: Chlorination. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

La Grange, Lenoir County

Ownership: Municipal. Population served: 1,800. Source: 2 wells (1 and 2) 238 and 321 feet deep. Well number 1 used for stand-by. The yield of the 2 wells is reported to be 300 and 250 gpm. Treatment: None. Ground storage: None. Elevated storage: 90,000 gallon elevated tank.

Lucama, Wilson County

Ownership: Municipal. Population served: 400. Source: 1 well 190 feet deep. The yield of the well is reported to be 50 gpm. Treatment: aeration, lime, clorination, rapid sand filtration, and coke. Ground storage: 3,000 gallon concrete reservoir. Elevated storage: 100,000 gallon elevated tank.

Middlesex, Nash County

Ownership: Municipal. Population served: 525. Source: 2 wells (1 and 2) 86 and 74 feet deep. The yield of the 2 wells is reported to be 30 gpm each. Treatment: Calgon. Ground water storage: None. Elevated storage: 30,000 gallon elevated tank.

Morehead City, Carteret County

Ownership: Carolina Water Company. Population served: 5,444. Source: 6 wells (Nos. 1-6) 250, 525, 129, 247, 250, and 230 feet deep. Well number 6 is reported to yield 365 gpm. Treatment: Chlorination. Ground storage: None. Elevated storage: 65,000 gallon elevated tank.

Mount Olive, Wayne County

Ownership: Municipal. Population served: 4,000. Source: 4 wells (Nos. 1-4) 135, 170, 175, and 282 feet deep. The yield of the wells is reported to be 90, 160, 150, and 800 gpm. Treatment: Chlorination. Ground storage: 2 concrete reservoirs: 100,000 gallon and 15,000 gallon. Elevated storage: 75,000 gallon elevated tank.

New Bern, Craven County

Ownership: Municipal. Population served: 17,380. Source: 12 wells (Nos. 1-12) 90 to 115 feet deep. The total yield of the wells is reported to be 3,100 gpm. Treatment: Zeolite softening, ammoniation, and chlorination. Rated capacity of treatment plant: 2,000,000 gpd. Raw-water storage: None. Ground storage: 300,000 gallon reservoir. Elevated storage: 100,000 gallon elevated tank.

Pink Hill, Lenoir County

Ownership: Municipal. Population served: 450. Source: 1 well 220 feet deep. The yield of the well is reported to be 250 gpm. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Pikeville, Wayne County

Ownership: Municipal. Population served: 500. Source: 5 wells (Nos. 1-5) 257, 22, 20, 87, and 90 feet deep. The yield is reported to be 10, 15, 15, 100, and 100 gpm. Treatment: Calgon and chlorination. Ground storage: 3 clear water wells. Elevated storage: 75,000 gallon elevated tank.

Princeton, Johnston County

Ownership: Municipal. Population served: 655. Source: 2 wells (1 and 2) 141 and 236 feet deep. The yield is reported to be 60 and 80 gpm. Treatment: None. Ground storage: 1 clear water well. Elevated storage: 75,000 gallon elevated tank.

Raleigh, Wake County

Ownership: Municipal. Population served: about 73,500. Source: Walnut Creek impounded in Lakes Raleigh and Johnson. Swift Creek impounded in Rands Mill reservoir. Treatment: Coagulation with alum, ammoniation (ammonium sulfate), prechlorination, sedimentation, activated carbon, rapid sand filtration, adjustment of pH with lime, and postchlorination. Rated capacity of treatment plant: 13,000,000 gpd. Ground storage: 2 clear wells, 2,000,000 and 2,400,000 gallons. Elevated storage: 3 elevated tanks, 100,000, 600,000, and 750,000 gallons. Location of treatment plant: 1 mile south of Raleigh on the old Fayetteville Road.

Selma, Johnston County

Ownership: Municipal. Population served: 2,600. Source: 5 wells (Nos. 3-7) 181, 305, 300, 291, and 275 feet deep. The yield is reported to be 180, 350, 300, 100, and 200 gpm. Treatment: Pressure filtered, caustic soda to pH 9.2, and chlorination. Ground storage: 8,000 gallon reservoir. Elevated storage: 75,000 gallon elevated tank.

Smithfield, Johnston County

Ownership: Municipal. Population served: 5,700. Source: Neuse River. Treatment: Coagulation with alum, soda ash, prechlorination, activated carbon, rapid sand filtration, adjustment of pH with lime, and postchlorination. Rated capacity of treatment plant: 1,000,000 gpd. Ground storage: 200,000 gallon clear water well. Elevated storage: 2 elevated tanks, 100,000 and 300,000 gallons. Location of treatment plant: Northwest Smithfield on Neuse River.

Snow Hill, Greene County

Ownership: Carolina Water Company. Population served: 1,000. Source: 1 well 260 feet deep. The yield is reported to be 340 gpm. Treatment: None. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Stantonsburg, Wilson County

Ownership: Municipal. Population served: 750. Source: 2 wells (1 and 3) 165 and 150 feet deep. The yield is reported to be 300 and 80 gpm. Treatment: None. Ground storage: None. Elevated storage: 30,000 gallon elevated tank.

Wake Forest, Wake County

Ownership: Municipal. Population served: 4,400. Source: Smith Creek and Alston Branch impounded. Treatment: Coagulation with alum and lime, rapid sand filtration, and chlorination rated capacity of filtration plant 450,000 gpd.

Walstonburg, Greene County

Ownership: Municipal. Population served: 250. Source: 1 well 210 feet deep. Treatment: None. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Wendell, Wake County

Ownership: Municipal. Population served: 1,690. Source: 4 wells (Nos. 1-4) 301, 602, 301, and 100 feet deep. The yield is reported to be 40, 30, 20, and 60 gpm. Treatment: None. Ground storage: None. Elevated storage: 100,000 gallon elevated tank.

Wilson, Wilson County

Ownership: Municipal. Population served: 25,000. Source: Contentnea Creek and Toisnot Swamp. Treatment: Prechlorination, coagulation with alum, lime (if necessary), sedimentation, rapid sand filtration, ammoniation, calgon, postchlorination, and adjustment of pH with lime. Rated capacity of treatment plant: 4,000,000 gpd. Raw-water storage: None. Finished water storage: 1 reservoir, 2,000,000 gallons; 1 elevated tank, 1,000,000 gallons. During dry periods supply is supplemented from Tar River. One well has been drilled to be used as emergency supply.

Winterville, Pitt County

Ownership: Municipal. Population served: 1,000. Source: 2 wells (1 and 2) 157 and 304 feet deep. The yield is reported to be 80 and 300 gpm. Treatment: Well number 1 - zeolite softener filter; well number 2 - no treatment. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Youngsville, Franklin County

Ownership: Municipal. Population served: 660. Source: 1 well 300 feet deep. The yield is reported to be 75 gpm. Treatment: Calgon. Ground storage: None. Elevated storage: 75,000 gallon elevated tank.

Zebulon, Wake County

Ownership: Municipal. Population served: 1,486. Source: 4 wells (Nos. 1-4) 312, 250, 190, and 150 feet deep. The yield is reported to be 100, 45, 90, and 50 gpm. Supplemental supply: Little River. Treatment: Wells - None. All wells pumped directly into distribution system. Little River - lime, alum, rapid sand filtration, and chlorination. Rated capacity of treatment plant: 200,000 gpd. Ground storage: 100,000 gallon clear well. Elevated storage: 100,000 gallon elevated tank.

Other Uses -- One of the more important uses of surface waters in the Neuse River Basin is for waste disposal by industries and municipalities. Navigation in certain areas, and recreational activities in those and other areas, constitute a significant use.

In addition to the uses of ground water indicated above, wells are used as the source of supply for a variety of uses, including motels, laundries, and air conditioning. These miscellaneous uses of ground water account for an estimated five million gallons per day.

Summary of Water Use -- The total withdrawal of surface water for all uses, except water power, probably is in the order of 200 mgd. Total withdrawals of ground water aggregate about 80 mgd.

Potential Supply of Surface Water - - At the present time, the demand for surface waters of suitable quantity and quality is increasing rapidly. The large industrial growth in the State, gains in population, greater use of automatic home appliances, and widespread installation of irrigation equipment have caused an upsurge in the use of water. The withdrawal of surface waters for these uses may be expected to increase in the future.

The present sources of surface water generally appear to be adequate to provide the quantities required in the near future for the continued growth of the area. Although it is probable that in most places the present withdrawal can be increased several times without danger of a shortage of supply, minimum stream yields in many localities will be grossly exceeded by the demand for water, and additional storage facilities will be necessary. The adequacy of the surface-water supplies in several localities will depend in large measure upon the activities being directed toward pollution abatement. In the lower reaches of the Neuse and Trent Rivers and Swift Creek, water supplies must be located carefully to avoid serious contamination by salt water.

Rainfall deficiencies during recent growing seasons have led to increase in the volumes of water used for irrigation, and it may be expected that similar rainfall deficiencies in the future will necessitate additional irrigation. Although irrigation will not be practiced in North Carolina on as large a scale as is done in western states because of its humid climate, supplementary irrigation will undoubtedly be continued on an increasing scale.

Ground Water - - Preliminary studies indicate that the quantity of water now withdrawn from ground-water reservoirs in the Neuse River Basin is but a fraction of the total available supply. A great expansion of present ground-water developments is feasible throughout the basin.

An exact determination of the potential ground-water supply that may be utilized in any given area can be made only by interpreting hydrologic data of many kinds, collected over a period of years. The ground-water program in North Carolina has been limited so far to general studies, so that detailed knowledge of the properties of the aquifers has not been obtained. Sufficient information is available, however, to suggest areas of possible expansion and to point out certain limitations on development.

Domestic ground-water supplies may be obtained generally throughout the Neuse River Basin and present no great problem. Moderate supplies for municipal, industrial, or agricultural use are available at many places in the Piedmont and upper Coastal Plain, and large supplies may be obtained throughout the area underlain by the sands of Cretaceous age and limestones of Tertiary age. There are, however, two important restrictions on ground water use in the basin which must be mentioned -- spacing of wells and salt-water contamination.

When a well is pumped, the water level is lowered at the well so that water flows toward it from all directions. The distance from the well, to which a measurable effect of pumping extends, depends on the rate of pumping. Wells must, therefore, be properly spaced to prevent mutual interference Because so many factors are involved in the proper spacing of wells, they cannot be discussed in this publication. This problem is not too serious in

the Piedmont or Fall Zone provinces where the permeability is relatively low and yields are small. In the area underlain by the very permeable sands of Cretaceous age and limestones of Tertiary age, however, where large yields are expected, the problem is more acute, especially as it relates to salt-water contamination.

From the vicinity of Dover, in Craven County, to the coast, it is known that a body of salt water lies beneath the fresh water in the underground reservoir. There are certain physical relationships between these bodies of water which may be briefly applied as follows: Under ideal conditions, and at any given well site, for every foot of drawdown of the fresh water level, the salt water level will ultimately rise 40 feet. It is very important, therefore, that wells be properly spaced, not only to prevent their interfering with production from other wells, but also to prevent their combined production from lowering water levels so much as to allow salt water to rise into the wells, rendering them unfit for use.

In that part of the Neuse River Basin where salt-water contamination is possible, most wells have excellent yields, some furnishing as much as 1 mgd. Under present conditions, heavy pumping may be safely continued or, at some places, increased without danger of contamination. Generally, it may be said that an industry requiring 0.25 to 1 mgd may rely upon a private ground water supply. Because of the necessity of spacing wells some distance apart, it may not be possible for an industry to have several heavily pumped wells on its property, whereas a municipality, being able to space its wells over several square miles, may furnish several additional millions of gallons daily for public use, including industrial use.

It must be emphasized, however, that geologic and hydrologic conditions differ enough from place to place to prevent the application of a "formula" which may govern all cases. Before installing a large ground-water system, a municipality or an industry should obtain as much information as possible about the geology of the acquifer and its known hydrologic properties. It may be necessary to drill several test holes to determine the depth to the salt-water body and the possibility of contamination. Although the potential supply of ground water is large and its withdrawal may be safely increased to the greatest extent in the southeastern half of the Neuse River Basin, each large installation should be given individual study and should be planned in consideration of other installations in the same general area.

Table III of this chapter lists private industrial water supplies, furnishing approximately 207 mgd.

TABLE III
PRIVATE WATER SUPPLIES - INDUSTRIAL
MARCH 1955

Industry	Ownership	Est. Use M.G.D.	Ground	Surface Source
Appel Poultry - Durham	P	.002	Wells	
Bellevue Mfg. Co. - Hillsboro	P	.040		Unnamed Creek
C. P. & L. Steam Plant - Goldsboro	P	108.000		Neuse River
Dupont - Kinston	P	.096		Neuse River
Efland Knitting - Efland	P	.001	Wells	
Eno Steam Plant - Durham	P	96.5		Eno River
Farmers Exchange Livestock Mkt. - Hillsboro	P	.007	Wells	
Hardee Hatchery - Durham	P	.002	Wells	
Jones Sausage - Garner	P	.005	Wells	
Piedmont Packing Co. - Hillsboro	P	.008	Wells	
Somerset Mills, Inc. - Roxboro	P	.004	Wells	
Taylor Food Company - Cary	P	.016	Wells	
Wake Finishing Co. - Raleigh	P	2.200		Neuse River
		206.881		

CHAPTER V -- USE OF WATER FOR RECREATION

State Parks -- The Division of State Parks, Department of Conservation and Development, operates, maintains, and administers nine State Parks, of which three, Cliffs of the Neuse State Park, William B. Umstead State Park, and Reedy Creek State Park, are located in the Neuse River Basin.

The three State Parks, indicated above, are open seven days per week throughout the year for picknicking, hiking, nature study, sightseeing, and similar uses. Swimming facilities and refreshment stands are operated from June 1 through Labor Day. Admission to, and parking in, the State Parks are free.

Developed tent and trailer campgrounds are available in William B. Umstead State Park and are operated from about March 15 to about November 1, depending on weather conditions. Fee for the use of the campgrounds is $1.00 per day for each camp site. Each camp ground has a road through it over which the camper may drive his car (and trailer) directly to the individual camp sites. Each camp site is equipped with table and bench, outdoor fireplace, and parking space for car or trailer. Each campground has a central washhouse with lavatories, flush toilets, and showers for men and women, and built-in laundry washtubs. Sewage-disposal and water-supply facilities are approved by the North Carolina State Board of Health. Electrical, sewage, and water connections for trailers are not available.

The minimum length of stay in North Carolina State Parks is one day. The maximum length of stay is two weeks, unless a vacancy makes it possible to extend the maximum period. Camping in, and use of, State Parks is governed by the North Carolina State Parks Regulations which are posted in each washhouse. Tents must be neatly and securely pitched in designated camping areas. Fires must be built only in the outdoor fireplaces. Wood may be purchased at each park for a small fee. Groceries and other supplies may be secured from towns in the vicinity of the parks. Fishing in the parks is subject to rules and regulations of the North Carolina Wildlife Resources Commission. Swimming facilities are available from June 1 through Labor Day at Cliffs of the Neuse State Park and Reedy Creek State Park. Three Organized Group Camps at William B. Umstead State Park, and one at Reedy Creek State Park, are available for organizations such as Boy Scouts, Girl Scouts, YMCAs, YWCAs, 4-H Clubs, and church organizations.

William B. Umstead State Park -- This park is located in Wake County, on U. S. Highway 70, twelve miles from Durham, and covers 3,886 acres. The park is one of the most beautiful areas in the eastern edge of the Piedmont Plateau, is heavily wooded, and contains quite rugged topography, and several picturesque streams.

Both plant and animal life are interesting and varied. Some of the wooded areas are pure pine stands, others are mixed pines and hardwoods, and still others are entirely hardwoods. A variety of trees and shrubs, from the beautiful dogwood to the towering tulip poplar, are within the park, as is also a variety of wild flowers. Animals and birds include racoon, fox, opossum, squirrel, muskrat, rabbit, wild turkey, quail, several species of owls, and a host of songbirds; whippoorwills are heard on summer nights. This varied plant and animal life makes the area very interesting for outdoor recreation.

A park road system extends to all developed public use facilities. Parking areas are available at picnic areas. Fishing is permitted in streams during the entire season, and in the 21-acre lake from Labor Day to June 1. The lake is closed to fishing during June, July, and August. The three Organized Group Camps are on the shores of the lake.

Cliffs of the Neuse State Park --This park is on the banks of the Neuse River in Wayne County, 14 miles southeast of Goldsboro on North Carolina Highway No. 111. It was acquired by gift in 1945 and was established as a state park for the preservation of distinctive scenic and natural features and the provision of facilities for outdoor recreation. It includes 321 acres and lies on both sides of the Neuse River. The most striking natural feature is the cliffs, rising 90 feet above the Neuse River. These cliffs are a unique geological feature in this section of the State. This state park is very interesting botanically because of the unusual mixture of plants, trees, and shrubs which it contains. Mountain galax, most unusual in the Eastern part of the State, and mountain laurel contrast with Spanish moss. Beech, hickory, gum, and several species of oak and pine are among the many species of trees in the park. In season, the flowering plants include dogwood, redbud, laurel, and many other flowering shrubs and herbaceous plants. Bobwhites and numerous songbirds frequent the park, and the animals include racoon, squirrel, opossum, and muskrat.

Two clear streams flow through the park and are accessible by foot trail. A lake, which affords swimming, fishing, and boating, has been created on one of these streams. The swimming facilities at the lake include a bathhouse, a sand beach, and a protected bathing area. These facilities are open from June 1 through Labor Day. Fishing for bass and panfish is available in the lake and in the Neuse River.

A paved park road system extends to all developed public use facilities. Paved parking areas serve the Cliffs Overlook area, the picnic area, and the swimming area. The picnic area is equipped with picnic shelter, tables and benches, outdoor fireplaces, water, and toilets. Limited tent camping is permitted. There are no developed campgrounds.

Reedy Creek State Park -- This park is in Wake County, near Raleigh. It is reached from U. S. Highway 1 by turning north over a paved road at the North Carolina State Fairground. It is maintained and operated for Negro use. It covers 1,234 acres and is one of the most beautiful wooded areas in the eastern edge of the Piedmont Plateau. Its forest growths include stands of pine, mixed hardwood and pine stands, and stands composed entirely of hardwoods. With its forest growth, its quite rugged topography, and its picturesque streams, it is an outstanding example of Eastern Piedmont landscape.

The park has an abundance of plant and animal life; several species of pine and oak, hickory, black gum, sweet gum, and tulip trees are only a few of the different kinds of trees in the park. Dogwood, redbud, and mountain laurel are numbered among the shrubs in addition to many herbaceous plants. Animal and bird life is abundant. Fox, squirrel, rabbit, racoon, opossum, and muskrat inhabit the park. Turkey, quail, several species of owls and hawks, and many songbirds may be seen. Situated in the heavily populated Raleigh-Durham area, Reedy Creek State Park is within a short driving distance of many people. Its opportunities for group camping, outings, day-use, and the study of natural sciences are excellent.

The swimming pool area contains a large, modern swimming pool and a bathhouse, and is open from June 1 through Labor Day. The picnic area is equipped with picnic shelter, tables and benches, outdoor fireplaces, water, and toilets. The park road system extends to all developed public use facilities. Parking areas are available near the picnic area and the swimming pool.

Municipal Parks -- It is estimated that there are about 100 municipal parks in the Neuse River Basin, which provide recreational facilities, including tennis, softball, and swimming. Durham, the largest city in the basin, has 22 parks. Nine cities and towns in the basin have a population consisting of approximately 40 per cent of the total basin population. These nine cities and towns have Municipal Recreation Centers, the superintendents and directors of which are under the supervision of the State Recreation Commission.

Coastal Area Recreation Facilities -- The coastal area adjacent to the Neuse River Basin includes the Outer Banks from Drum Inlet to Hatteras Inlet, part of the Atlantic Intracoastal Waterway from Bay River, a tributary of Neuse River, to Pamlico River, and parts of Core Sound and Pamlico Sound, the latter being the largest sound in the State and having an area of approximately 1200 square miles. A part of the Atlantic Intracoastal Waterway from Neuse River to Newport River, which provides access by boats to the recreational areas of Morehead City, Beaufort, and Atlantic Beach over a very short distance in comparison with the route through Pamlico Sound and Core Sound, also lies in the Neuse River Basin. The Eastern Carolina Yacht Club Regatta and outboard-motor boat races are held annually at New Bern. The recreational facilities in this area attract tourists from many states, and the revenue derived from them, in addition to that from commercial fishing, adds greatly to the prosperity of the region.

Lakes -- There are 30 natural, and 21 man-made, lakes in the Neuse River Basin, the largest of which are Lake Michie on Flat River in Durham County; Lake Mirl on Hodges Creek, Neuseca Lake on Beaverdam Creek, Lake Johnson and Lake Raleigh on Walnut Creek, Sunset Lake on Middle Creek, and Lake Myra on Marks Creek, in Wake County; Holt Lake on Black Creek and Lake Wendell on Buffalo Creek, in Johnston County; Silver Lake, a part of Toisnot Swamp, in Wilson County; Long Lake, Little Lake, and Ellis Lake, within the boundary of Croatan National Forest, in Craven County; and Catfish Lake, also within the boundary of Croatan National Forest and lying partly in Craven County and partly in Jones County.

Facilities for recreation in the form of swimming, fishing and boating are available in a considerable number of the 51 lakes indicated above.

CHAPTER VI -- USE OF WATER FOR HYDROELECTRIC POWER

House Document No. 500, 72nd Congress, 2nd Session, "Improvement and Development of the Neuse River", N. C., published in 1932, contains the following information regarding development of hydroelectric power in the Neuse River Basin.

Previous Reports on Water Power -- In 1899, the North Carolina Geological Survey (predecessor of the present North Carolina Department of Conservation and Development) issued a bulletin entitled "Water Power in North Carolina." Chapter VI of this bulletin refers partly to the Neuse River and its tributaries. This chapter contains a description of the streams, their potential water power, the rainfall of the area, and a description of the plants in operation at that time. Brief mention of the power on this stream is also made in several of the "Water Supply Papers" and annual reports of the United States Geological Survey. Except for these, no reports which directly concern the water power of this area were discovered.

Factors Influencing the Development of Water Power -- As shown by their discharge records, these streams are subject to long periods of low flow and frequently to floods during wet years. Also, except at the Falls of the Neuse in Wake County and at the points where the lower tributaries of the main stream cross "the fall line" (a zone fifteen to twenty miles wide, in which streams pass from the crystalline rocks of the Piedmont Plateau on to the unconsolidated sediments of the Coastal Plain), no concentrated head is available below sizable drainage areas, and, therefore, few natural sites exist. The main stream has no falls or rapids at the "fall line", as have most of the streams of the Atlantic coastal plain. These factors have had the effect of causing the larger power interests to install their power plants on other streams where more constant flow is available, better natural sites exist, and appreciable storage could be more economically obtained.

Also, in recent years there has been a tendency toward centralized production of large plants and the distribution of electrical energy by transmission lines. These lines cover practically the entire territory adjacent to the Neuse River, and, as the rates for this type of power are comparatively low, many small isolated water-power developments on the streams in this area have recently been abandoned.

Existing Water-Power Developments -- The only water-power plant of any magnitude on this stream or its tributaries is the Flat River development belonging to the City of Durham. This plant is located near Bahama in Durham County. It develops a maximum head of approximately 70 feet and has an installed capacity of 1,500 kilowatts. The dam impounds about 14,000 acre-feet of water (known as Lake Michie). As the plant was primarily constructed to furnish Durham with an adequate water supply, practically none of the storage is used for power development, the power equipment having been installed to utilize only the water not needed for municipal purposes.

A minor development exists at the Falls of the Neuse in Wake County where a small cotton mill is operated partially by water power. Two other developments formerly existed on the main stream in Wake County and also one in Johnston County. These developments have been abandoned.

The City of Wilson owns a small development on Contentnea Creek near that city. The dam impounds about 2,500 acre-feet of water and develops a head of 11 feet. The pool, besides furnishing water for the city, furnishes pondage for the power plant. The plant stores during the day, operating only at times of peak load as a voltage booster for the local steam plant. The installed capacity of the development is 250 kilowatts. It was also built primarily for municipal water supply purposes.

The other plants in the area are found on the smaller tributaries and are, for the most part, small water wheels which operate gristmills, sawmills, cotton gins, etc. The capacity of these plants is small, and their equipment is generally out of date. A number have recently been abandoned.

Market for Power -- It has been assumed that the territory which could be served economically by power developments in the Neuse River Basin embraces an area within a 50-mile radius of the City of Raleigh. Among the larger cities within economical transmission distance of the proposed developments are Durham, Raleigh, Rocky Mount, Fayetteville, Goldsboro, and Wilson. The population of the area in 1930 was approximately 650,000.

The bulk of the power, consumed in this market, with the exception of small quantities produced by municipal plants and a few independents, is supplied by the Duke Power Company and the Carolina Power and Light Company. These companies, which operate numerous hydroelectric and steam plants, are connected by a vast transmission system with the other large power interests of the State, by means of which all of them interchange and market power. In their manner of operation, these companies may be considered as one power system, supplying practically the entire State of North Carolina. Any power plant installed in this area, unless it be for some special purpose, must either compete with or form a part of this power system.

Proposed Power Developments -- On account of the small drainage areas of the streams, their variable flow, and their lack of concentrated fall, the production of appreciable quantities of continuous power on the Neuse River and its tributaries is impossible without storage. However, if sufficient storage, with which to maintain a constant rate of flow in the streams over extended dry periods, can be obtained economically, their gradients are sufficiently steep to be capable of producing comparatively large amounts of electrical energy. Therefore, the problem resolved itself into providing such storage, located so that it can be used in connection with the greatest amount of head that can be economically developed. With this problem in view, a number of sites capable of providing storage and head were examined, and those believed to be best adapted for a comprehensive plan of development were selected for survey and study.

The proposed plan embodies the construction of six projects, the locations of which are at the Falls of the Neuse, Milburnie, Wilson Mills, and Smithfield on the Neuse River, Bakers Mill on Little River near Princeton, and Wiggins Mill on Contentnea Creek near Wilson.

Conclusions Regarding the Feasibility of the Plan of Development-- A comparison of the annual benefits with the annual charges shows that the revenue to be anticipated from the proposed power scheme as a whole would not warrant the expenditure that would be required for its installation. Some of the individual projects, embodied in the proposed plan, might at some future date become feasible should fuel costs become higher. If any such project should be installed, its effect on the flood heights of the stream below should be given careful consideration.

Streamflow -- During its history, the Neuse River has played an important part in the development of the region. From the time of the early settlements when New Bern was the Colonial Capital, the river was the artery upon which ships traveled inland. As shipping diminished, the river and its tributaries assumed additional roles in supplying water for municipal and industrial use, generation of electric power, recreation, and other purposes.

The rivers and creeks are valuable assets; at times, however, they can develop into liabilities. There have been occasions when streamflow was inadequate to meet the established requirements of many users in the basin. At still other times, floods have menaced extensive areas, particularly in the lower reaches.

Basic streamflow information consists of continuous records of flow at gaging stations on the rivers and smaller streams. At present, 14 gaging stations are operated within the basin, some of which have been maintained since 1925. On many small streams where no continuous records of flow are available, measurements of streamflow have been made during periods of low flows to supply a more complete coverage of the area. Records of daily flows and results of miscellaneous measurements are published in annual Water-Supply Papers of the U. S. Geological Survey. Gaging stations at which continuous records of flow are not collected are known as partial-record stations. A figure, showing the duration of records at the 14 complete-record gaging stations, and a map of the basin, indicating the locations of complete-record and partial-record gaging stations and quality-of-water-sampling sites, may be found in the report in preparation by the United States Geological-Survey, referred to in the bibliography herein. Data, pertinent to these gaging stations and sampling sites, are shown on Table I of this chapter.

In general, the flow of the streams in the Neuse River Basin is affected little by the control works of man. Among the exceptions are the effects of Lake Michie on Flat River and a storage reservoir on Contentnea Creek. The flow of Flat River below Lake Michie is regulated by operation of the hydroelectric plant and by diversion of water from the City of Durham. Waste water from Durham is discharged into the Cape Fear River Basin and into the Neuse River below Flat River. The flow of Contentnea Creek is regulated by the operation of the hydroelectric plant, and by diversion of water, for the City of Wilson.

The design of hydraulic works must consider the variations in streamflow. Most water shortages that have occurred in recent years were the result of planning on the basis of inadequate data or of increased demands outrunning the expansion of facilities. Water shortages generally occur only at times when stream runoff is considerably below normal, and they are often mistakenly referred to as drought shortages when they really should be described as resulting from inadequate planning.

In analyzing the adequacy of a specific source for water supply, the requirements will be known for water consumption or for waste disposal. To meet these requirements, the per cent of time the flow is sufficient to meet the needs must be determined. Information is also required on how frequently the flow will be insufficient, how long the deficiency will persist, and what storage will be required to meet the deficiency.

TABLE I-Stream-gaging sites and quality-of-water-sampling sites in the Neuse River Basin.

Stream	Drainage Area (Sq. miles)	Type and length of Record: Discharge Type	Discharge No. yrs.	Chemical Quality Type	Chemical Quality Water Yr.	Location
Eno River	66.5	Daily	26			Orange County, lat 36° 04', long. 79° 06' 1,000 ft. below bridge on State Highway 86 at Hillsboro, and 2 miles below Sevenmile Creek.
Flat River	150	Daily	28			Durham County, lat 36° 11' 00", long. 78°52' 45", ½ mile above Lake Michie, 1¼ miles north of Bahama, and 1½ miles above Dial Creek.
Dial Creek	4.9	Daily	28			Durham County, lat 36° 10' 35", long. 78° 51' 20", 3/8 mile above mouth and Lake Michie, and 1½ miles northeast of Bahama.
Flat River	171	Daily	26			Durham County, lat 36° 08' 55", long. 78°49' 43", 900 ft. below Durham municipal dam, 3 miles southeast of Bahama, and 5 miles above Eno River.
Neuse River	526	Daily	26			Granville County, lat 36° 02' 07", long. 78° 44' 59", at Fish Dam bridge, 1½ miles south of Northside.
Lower Barton	13.2	Partial	3			Wake County, lat 35° 58' 01", long, 78° 38' 08", at highway bridge 1/4 mile above mouth, 1 3/4 miles north of Bayleaf, and 3½ miles northeast of Falls.
Horse Creek	21.0	Partial	5			Wake County, lat 35° 58' 10", long, 78° 35' 30", at bridge on U. S. Hgwy. 264, 1 mile above mouth, and 4½ miles west of Wake Forest.
Crabtree Creek	97.8	Partial	5			Wake County, lat 35° 50' 15" long. 78° 40' 45" at U. S. Hgwy.15A 4½ miles northwest of Raleigh.
Mine Creek	8.75	Partial	3			Wake County, lat 35° 51' 19" long. 78° 39' 43" 1¼ miles above mouth, and 3¼ miles west of Millbrook.

TABLE I--Stream-gaging sites and quality of water sampling sites in the Neuse River Basin.--(Continued)

Stream	Drainage Area (Sq. miles)	Type and length of Record: Discharge Type	Discharge No. years	Chemical Quality Type	Chemical Quality Water Yr.	Location
Big Branch	3.90	Partial	3			Wake County, lat 35° 49' 18' long, 78°37' 47", at culvert on Six Forks Road, ¼ mile above mouth 2 3/4 miles southwest of Millbrook.
Neuse River	1,140	Daily	26	Daily	1944	Johnston County, lat 35° 39', long. 78° 25' at State Highway, 42, 3 miles east of Clayton.
Swift Creek	53.9	Partial	5			Wake County, lat 35° 41' long. 78° 39' at highway bridge ½ mile below unnamed creek, and 2½ miles northeast of McCullers.
Middle Creek	80.7	Daily	14			Johnston County, lat 35° 34' 10", long. 78° 35' 30" at State Highway 50, ¼ mile above Buffalo Branch, and 9½ miles south west of Clayton.
Middle Creek	124	Partial	5			Johnston County, lat 35° 30' long. 78° 24' at bridge on State Hgwy. 210, 1½ miles above mouth and 3 miles west of Smithfield.
Black Creek	79.0	Partial	5			Johnston County, lat 35° 08' 28" long. 78° 27', 25", at highway bridge 2¼ miles west of Four Oaks, and 5 miles above mouth.
Buck Swamp	17.0	Partial	5			Wayne County, lat 35° 16', long. 78° 05' at highway bridge 1½ miles above mouth and 2½ miles west of Dudley.
Little River	229	Daily	23	Monthly	1951	Johnston County, lat 35° 20' 20", long. 78° 09' 30', 3/4 miles above Little Creek and 3 miles north of Princeton.
Neuse River	2,390	Daily	23	Daily	1949	Wayne County, lat 35° 20', long. 78° 00', at Hgwy. bridge, 0.2 mile above Stony Creek and 3 miles south of Goldsboro.
Stony Creek	21.0	Partial	5			Wayne County, lat 35° 23', long. 77° 58' at bridge on U. S. Hgwy. 70, 2 miles east of Goldsboro.

TABLE I--Stream-gaging sites and quality of water sampling sites in the Neuse River Basin.--(Continued)

Stream	Drainage Area (Sq. miles)	Type and length of Record: Discharge Type	Discharge No. yrs.	Chemical Quality Type	Chemical Quality Water Yr.	Location
Falling Creek	45.4	Partial	5			Lenoir County, lat 35°15' 40", long, 77° 41'30", at bridge on U. S. Highway 70, at Falling Creek.
Neuse River	2,690	Daily	23	Daily	1950	Lenoir County, lat 35° 15' 30", long. 77° 35' 10", at Kinston, 600 feet below bridge on State Highway 11.
Deep Run Creek	6.1	Partial	5			Lenoir County, lat 35° 08', long. 77° 42' at highway bridge ½ mile above mouth and 0.7 mile east of Deep Run.
Moccasin Creek	28.2	Partial	4			Nash County, lat 35° 49' long. 78° 15' 3¼ miles northwest of Middlesex and 9 miles above Turkey Creek.
Contentnea Creek	236	Daily	23			Wilson County, lat 35° 41' 15", long. 77° 56' 50" at bridge on U. S. Hgwy. 301 just below municipal power plant, and 3 miles southwest of Wilson.
Nahunta Swamp	97.1	Partial	5			Greene County, lat 35° 30' 30", long. 77° 44' 35" at bridge on State Hgwy. 58, 3/4 mile above mouth, and 5 3/4 miles northwest of Snow Hill.
Contentnea Creek	789	Daily	25	Daily	1950	Greene County, lat 35° 25' 40", long. 77° 35' 05", at Hookerton , 0.3 mile above bridge on State Highway 123.
Core Creek	59.2	Partial	5			Craven County, lat 35°15' 10' long 77° 17' 10" at bridge on State Hgwy. 55, 3 3/4 miles southwest of Fort Barnwell and 7 miles above mouth.
Swift Creek	182	Daily	3	Monthly Daily	1951 1952	Craven County, lat 35°20' 42" long. 77° 11' 44", at highway bridge 2½ miles below Clayroot Swamp, and 3½ miles north west of Vanceboro.
Trent River	168	Daily	2	Daily	1952-53	Jones County, lat 35° 03' 54 "long 77° 27' 25", at Free Bridge, 800 feet below Little Chinquapin Branch and 6 miles west of Trenton.

Flow Characteristics -- Streamflow varies greatly from day to day, season to season, and from year to year. The long-term average streamflow per unit of area, however, is relatively uniform over the entire Neuse River Basin. No significant long-term trend toward either an increase or decrease in the annual flow has been discovered during the period of record. In the Neuse River Basin, the average streamflow is approximately uniform per unit area (0.65 million gallons per day per square mile) for streams in the rocky Piedmont as well as for those in the sandy Coastal Plain. The high and low flows of streams in these two areas, however, reflect differences in rainfall, topography, geology, vegetation, size of drainage area, and other factors.

Curves showing streamflow characteristics are usually prepared for the period of record at the gaging site under study; however, these curves can be adjusted to longer periods by statistical methods using records on nearby streams. It is also possible to make a regional analysis of the data by statistical methods. A regional analysis is a study to make the best possible evaluation of the flow characteristics of a stream by taking into consideration records from nearby streams. Streamflow data in this chapter are generally for the base period, October 1, 1927 to September 30, 1953, and a regional analysis of the low-flow frequency data has been made.

Duration of Flow--In analysis of the flow characteristics of a stream, the flow-duration curve indicates the percentage of time during which a specified daily discharge was equaled or exceeded during the period of record. It shows the cumulative frequency of occurrence of different rates of flow at a given point. Assuming that future events will follow the pattern of flow measured in the past, the flow-duration curve may be used to estimate the probable occurrence of a specified discharge. Table II shows the drainage area in square miles, average discharge, and per cent of time the flow in the table was equaled or exceeded, for the complete-record and partial-record gaging stations in the Neuse River Basin during the period 1927-1953.

The slope of the flow-duration curve is a good index of the natural storage within a basin, including the ground-water storage; that is, the flatter the general slope of the curve, the lower the flood peaks and the higher the sustained dry-weather flow. Streams having a high dry-weather flow are the best for a source of water supply. A comparison of flow-duration curves for several streams in the basin shows which ones have the higher dry-weather flows. Curves showing duration of daily flow, Flat River at Bahama, Neuse River near Clayton, Middle Creek near Clayton, and Little River near Princeton, may be found in the report in preparation by the United States Geological Survey, referred to in the bibliography herein. The lower part of the curve for Neuse River near Clayton is the highest of the four and, therefore, indicates the best yield. The curve for Little River, near Princeton shows better sustained yield than those for the other stations illustrated.

As an example of the further use of flow-duration curves, assume that it is desired to locate an industrial plant on a site adjacent to Middle Creek at which the drainage area is 100 square miles, and that construction of a storage dam is not planned. Further assume that a flow of 2.5 mgd (0.025 mgd per square mile from 100 square miles) is required for plant operation. Inasmuch as the observed minimum flows are less than the required flow, it is necessary to know the probable number of days per year during which there

Table II-Duration table of deily flow in the Neuse River Besin, 1927-53
(Million gallons par day per square mile)

Caging Station	Dreinage area (Square miles)	Averege Discharge	Percent of time flow in table was equaled or exceeded																
			0.1	0.5	2	5	10	20	30	50	70	80	90	95	98	99	99.5	99.8	99.95
Eno River et Hillsboro	66.5	0.638	23.3	9.82	4.42	2.13	1.21	0.690	0.486	0.282	0.167	0.188	0.063	0.040	0.022	0.0082	0.0052	0.0039	0.0027
Flet River et Bahema*	150	.629	22.4	12.7	5.30	2.26	1.21	.646	.444	.241	.125	.081	.038	.019	.0069	.0042	.0031	.0023	.0018
Diel Creek neer Bahama	4.9	.579	19.0	10.3	4.09	1.91	1.11	.646	.462	.264	.138	.086	.030	.0032					
Flet River at dam, neer Bahema	171	.60	19.3	9.41	3.17	1.63	1.22	.765	.548	.265	.147	.061	.017	.0074	.0026				
Neuse Rivar neer Northside	526	.66	17.1	9.09	4.40	2.36	1.45	.811	.547	.289	.150	.100	.046	.023	.013	.0098	.0079	.0060	.0046
Lower Barton Creak near Baylaaf	13.2	.72							.695	.397	.264	.215	.176	.145	.118	.100	.085		
Horse Creek near Lake Forest	21.0	.70							.560	.409	.317	.274	.215	.182	.138	.122			
Crebtree Creek near Raleigh	97.8	.63							.628	.317	.159	.106	.056	.033	.017	.010			
Mine Creek near Millbrook	8.75	.67							.676	.389	.264	.220	.173	.145	.120	.105			
Big Brench near Millbrook	3.90	.68							.680	.381	.245	.204	.162	.138	.113	.096			
Neuse Aiver naer Clayton	1,140	.696	8.33	6.07	4.20	2.78	1.67	.884	.612	.380	.230	.164	.105	.074	.053	.044	.037	.032	
Swift Creek naer McCullers	53.9	.72							.695	.372	.192	.128	.074	.046	.025	.016	.0096		
Middle Creek near Clayton	80.7	.729	8.17	6.09	4.04	2.72	1.76	1.04	.705	.376	.192	.128	.074	.046	.025	.016	.0096	.0043	.00080
Middle Creek neer Smithfield	124	.72							.688	.375	.190	.128	.074	.047	.027	.018	.012		
Black Creek naer Four Oaks	79.0	.73							.687	.273	.069	.027	.0078	.0025					
Buck Swamp neer Dudley	17.0	.68							.684	.365	.186	.122	.063	.036	.017				
Little River near Princeton	229	.677		6.74	3.87	2.43	1.64	.988	.677	.373	.206	.144	.083	.053	.030	.019	.011	.0048	.0032
Neuse River near Goldsboro	2,390	.659				2.73	1.65	.865	.595	.373	.227	.162	.103	.070	.051	.042	.035	.030	.024
Stony Creek et Coldsboro	21.0	.68							.677	.375	.206	.145	.083	.054	.029	.019			
Felling Creek at Falling Creek	45.4	.67							.669	.384	.216	.155	.093	.061	.036				
Neuse River et Kinston	2,690	.674				2.81	1.68	.889	.625	.408	.259	.190	.125	.089	.065	.054	.047	.041	.034
Deep Run Creek at Deap Run	6.1	.74							.678	.477	.350	.275	.199	.152	.121	.103			
Moccesin Creek neer Middlesex	28.2	.73							.688	.378	.190	.128	.074	.045	.025	.016	.0096		
Contentnea Creek nr. Wilson **	236	.646	9.53	6.44	3.78	2.36	1.56	.945	.652	.334	.137	.071	.024	.0074	.0025	.0014			
Nahunta Swamp near Snow Hill	97.1	.67							.679	.366	.202	.142	.082	.053	.029	.019			
Contentnee Creek at Hookerton	789	.613			4.26	2.78	1.68	.876	.557	.311	.179	.121	.070	.046	.032	.025	.021	.017	.014
Core Creek near Fort Barnwell	59.2	.65							.644	.301	.140	.087	.043	.024	.011				
Swift Creek neer Vanceboro	182	.59							.522	.266	.138	.089	.043	.020	.0064	.0023	.00082		
Trent River near Trenton	168	.61							.550	.308	.169	.108	.058	.034	.022	.016	.013	.010	

* Period of record (1927-53) unadjusted for reguletion by Lake Michie end power plant or for diversion to City of Durham for municipel weter supply.
** Period of record (1930-53) unadjusted for reguletion by municipel reservoir and power plent or for diversion to City of Wilson for municipel weter supply.

will be a shortage of water. From the flow-duration curve for Middle Creek near Clayton, referred to in the preceding paragraph, a flow of 0.025 mgd per square mile would be available 98 per cent of the time. Thus, over a long period of time, there would be sufficient water on 98 per cent of the days and a shortage on 2 per cent of the days. The advantages of the proposed site, where a water shortage would occur 2 per cent of the time, could be weighed with alternate sites further downstream (larger drainage areas) or sites on other streams where the required flow would be available a greater portion of the time.

The flow-duration curve does not show whether or not the days of insufficient flow will be consecutive or how frequently shortages will occur. It may be possible to operate the plant for short periods on less than 2.5 mgd or, if not, possibly the plant can be shut down occasionally if the shortage does not occur too frequently. Therefore, more knowledge regarding the low-flow characteristics of the stream is required, including the frequency of insufficiency of flow, the durations of deficiencies, and the amount of storage required to provide the necessary flow.

Low-Flow Frequency -- The low-flow frequency curve indicates the average interval at which a specified discharge will occur as the lowest flow in the year. Curves for Flat River at Bahama, Neuse River near Clayton, Middle Creek near Clayton, and Little River near Princeton, showing recurrence intervals of annual low flows for periods of 1,7,30,60, and 90 consecutive days during the period April 1928 to March 1953, may be found in the report in preparation by the United States Geological Survey, referred to in the bibliography herein. These curves do not imply a regularity of occurrence but rather the probable average interval between specified low flows. Assuming that the flow during the period April 1928 to March 1953 was normal and that future events will follow the pattern of flow measured in the past, these curves may be used to predict the occurrence of future events. For example, the low-flow frequency curve for Neuse River near Clayton shows that the lowest flow in a year will be equal to or less than 0.046 mgd per square mile at an average interval of 5 years, or about 20 times in 100 years. The magnitude and frequency of low flows for the various periods, pertaining to all gaging sites in the Neuse River Basin, are shown in Table III.

The pattern of low flow in many streams becomes irregular in the lower reaches of the stream, owing to regulation of the discharge upstream. The regulation frequently causes a period of very low flow of short duration within a longer period of relatively uniform flow. The minimum daily flow of these streams is often considered too severe as a measure of the flow characteristics for many uses of the water. Where the regulation is minor and when it occurs in uniform weekly patterns, the average 7-day flow is a better indication of the flow characteristics of the stream. The lowest average 7-day flow for each year of records at gaging stations in the Neuse River Basin is shown in Table IV.

The low-frequency curves for Middle Creek near Clayton, referred to above, show that daily flow would be insufficient to satisfy the needs of the hypothetical industrial plant that requires 2.5 mgd (0.025 mgd per sq. mile from 100 square miles) at average intervals of 4 years. The average flow for 7 consecutive days would be insufficient at average intervals of 5 years, and the average flow for 90 consecutive days would be insufficient at average intervals of 22 years.

Table III - Magnitude and recurrence interval of annual low flows for periods indicated in the Neuse River basin, based on period 1928-53.

Gaging station	Min. daily discharge of record (mgd)	Discharge, in million gallons per day per square mile																	
		Daily flow						7-day flow						30 day flow					
		2 yr.	3 yr.	5 yr.	10 yr.	15 yr.	25 yr.	2 yr.	3 yr.	5 yr.	10 yr.	15 yr.	25 yr.	2 yr.	3 yr.	5 yr.	10 yr.	15 yr.	25 yr.
Eno River at Hillsboro	0.2	0.040	0.025	0.015				0.052	0.033	0.019				0.083	0.051	0.027	0.014	0.011	
Flat River at Bahama	.24	.020	.011	.0053	0.0025	0.0019	0.0014	.028	.016	.0073	0.0030	0.0023	0.0017	.052	.028	.012	.0049	.0038	0.0029
Diel Creek near Bahama	0							.022						.054	.021				
Neuse River near Northside	2.0	.032	.019	.011	.0063	.0052	.0042	.042	.026	.015	.0072	.0059	.0048	.066	.041	.021	.011	.0087	.0071
Lower Barton Creek near Bayleaf		.155	.131	.104				.172	.146	.117				.202	.170	.134	.100	.089	
Horse Creek near Wake Forest		.184	.157	.130				.202	.171	.141				.238	.198	.159	.127	.117	
Crabtree Creek near Raleigh		.037	.023	.011				.050	.031	.017				.075	.048	.025	.010	.0071	
Mine Creek near Millbrook		.150	.131	.108				.164	.142	.120				.191	.162	.133	.104	.095	
Big Branch near Millbrook		.143	.123	.099				.156	.134	.113				.179	.154	.126	.096	.088	
Neuse River near Clayton	29	.084	.064	.046	.032	.029	.026	.098	.075	.053	.036	.032	.028	.132	.097	.066	.044	.040	.035
Swift Creek near McCullers		.055	.035	.018				.073	.047	.025				.110	.071	.037	.016	.011	
Middle Creek near Clayton	.4	.054	.034	.018	.0042	.0019	.0007	.072	.046	.025	.0071	.0036	.0015	.108	.070	.037	.016	.011	.0072
Black Creek near Four Oaks		.003	.001					.006	.002					.018	.006	.001			
Buck Swamp near Dudley		.038	.024					.057	.033	.017				.085	.053	.027			
Little River near Princeton	.65	.059	.039	.021	.0071	.0045	.0003	.076	.051	.029	.010	.0068	.0041	.107	.073	.042	.019	.014	.0097
Middle Creek near Smithfield		.056	.036	.020	.005	.003		.073	.048	.027	.008	.005		.108	.071	.039	.018	.013	
Neuse River near Goldsboro	58	.082	.062	.045	.030	.027	.024	.097	.073	.051	.034	.030	.026	.130	.096	.064	.042	.038	.034
Stony Creek at Goldsboro		.059	.039	.021				.076	.050	.030				.108	.073	.042	.019	.014	
Falling Creek at Falling Creek		.067	.046					.085	.058	.035				.118	.082	.048			
Neuse River at Kinston	81	.099	.077	.057	.041	.037	.033	.116	.089	.065	.045	.040	.036	.151	.115	.080	.055	.050	.044
Deep Run Creek at Deep Run		.166	.135	.109				.189	.154	.120				.230	.183	.140	.105		
Moccasin Creek near Middlesex		.054	.034	.018				.072	.046	.025				.108	.070	.037	.016	.011	
Nahunta Swamp near Snow Hill		.059	.039	.021				.075	.050	.029				.106	.072	.041	.019	.014	
Contentnea Creek at Hookerton	8.4	.054	.039	.027	.018	.015	.013	.066	.048	.032	.020	.017	.015	.092	.065	.041	.026	.023	.019
Core Creek near Fort Barnwell		.027	.016					.037	.022	.011				.059	.035	.017			
Swift Creek near Vanceboro	1.0	.028	.013	.0032	.00028			.039	.021	.0065	.00060	.00023		.062	.038	.014	.0025	.0012	
Trent River near Trenton	1.9	.042	.028	.018	.011			.053	.036	.022	.012	.010		.079	.052	.030	.017	.014	

TABLE III-Magnitude and frequency of annual low flows in the Neuse River basin, based on period 1928-53,—continued.

Gaging Station	Discharge in million gallons per day per square mile											
	60 day flow						90-day flow					
	2 yr.	3 yr.	5 yr.	10 yr.	15 yr.	25 yr.	2 yr.	3 yr.	5 yr.	10 yr.	15 yr.	25 yr.
Eno River at Hillsboro	0.140	0.078	0.037	0.021	0.017	0.014	0.209	0.117	0.048	0.027	0.023	0.019
Flat River at Bahama	.099	.052	.018	.0086	.0065	.0049	.160	.086	.025	.012	.0091	.0069
Diel Creek near Bahama	.100	.053					.162	.087	.017			
Neuse River near Northside	.111	.068	.016	.016	.013	.011	.160	.096	.039	.021	.017	.014
Lower Barton Creek near Bayleaf	.242	.201	.153	.122	.112		.284	.227	.168	.135	.125	
Horse Creek near Wake Forest	.292	.243	.178	.148	.137		.348	.277	.195	.160	.149	
Crabtree Creek near Raleigh	.116	.073	.035	.019	.014		.159	.099	.046	.025	.020	
Mine Creek near Milltrook	.230	.191	.147	.123	.115		.265	.215	.161	.133	.126	
Big French near Milltrook	.212	.178	.141	.116	.108		.245	.199	.152	.126	.119	
Neuse River near Clayton	.184	.134	.081	.057	.051	.045	.232	.170	.096	.067	.060	.052
Swift Creek near McCullers	.164	.106	.053	.028	.022		.222	.144	.068	.038	.031	
Middle Creek near Clayton	.164	.104	.053	.028	.022	.016	.220	.143	.067	.038	.030	.024
Middle Creek near Smithfield	.164	.104	.054	.030	.024		.219	.143	.068	.040	.033	
Black Creek near Four Oaks	.047	.016	.003				.094	.034	.005	.001		
Buck Swamp near Dudley	.137	.084	.039	.019	.014		.187	.114	.051	.027	.021	
Little River near Princeton	.158	.106	.056	.032	.026	.019	.206	.137	.071	.042	.035	.027
Neuse River near Goldsboro	.178	.128	.178	.054	.049	.043	.227	.162	.094	.064	.057	.050
Stony Creek near Goldsboro	.158	.106	.056	.032	.026		.206	.137	.071	.042	.035	
Falling Creek at Falling Creek	.169	.117	.064	.038			.218	.147	.080	.048	.041	
Neuse River at Kinston	.207	.151	.097	.070	.062	.055	.254	.182	.113	.082	.072	.064
Deep Run Creek at Deep Run	.291	.228	.164	.125	.114		.346	.273	.185	.142	.129	
Moccasin Creek near Middlesex	.163	.103	.053	.028	.022		.218	.142	.067	.037	.030	
Nahunta Swamp near Snow Hill	.156	.104	.056	.032	.026		.203	.134	.070	.041	.035	
Contentnea Creek at Hookerton	.135	.091	.052	.034	.030	.026	.179	.122	.064	.042	.036	.031
Core Creek near Fort Barnwell	.098	.058	.025	.012	.0091		.139	.081	.034	.017	.012	
Swift Creek near Venceboro	.093	.061	.025	.0080	.0047		.139	.089	.037	.015	.0096	
Trent River near Trenton	.123	.077	.040	.023	.020		.169	.110	.051	.031	.026	

Table IV - Annual minimum 7-day flow at gaging stations in the Neuse River Basin
(Million gallons per day)

Year \ Index number and station	Eno River at Hillsboro	Flat River at Bahama	Dial Creek near Bahama	Flat River at dam, near Bahama	Neuse River near Northside	Neuse River near Clayton	Middle Creek near Clayton	Little River near Princeton	Neuse River near Goldsboro	Neuse River at Kinston	Contentnea Creek near Wilson	Contentnea Creek at Hookerton
1925-26		0.43	0.23									
1926-27		1.3	0									
1927-28		6.1	.03	0.54	28	138						
1928-29	4.2	4.6	.16	.30	22	91						
1929-30	8.6	15	.63	.72	70	277						210
1930-31	2.1	1.1	0	.45	7.6	68		5	116	200	1.0	43
1931-32	2.5	2.3	.01	.59	12	101		13	186	244	7.2	49
1932-33	.9	.27	0	1.0	2.4	34		.8	64	92	.1	9.3
1933-34	1.0	.36	0	.26	4.1	34		9	92	123	.1	12
1934-35	7.0	10	.26	2.3	60	165		25	283	426	18	81
1935-36	2.7	4.2	.13	3.3	16	96		16	180	348	6.1	71
1936-37	5.5	6.4	.28	2.4	34	169		18	310	487	8.7	79
1937-38	11.0	11	.44	0	52	239		30	478	512	14	66
1938-39	7.0	11	.46	4.1	21	131		27	353	488	16	70
1939-40	8.8	9.7	.70	2.7	51	190		26	333	443	15	88
1940-41	3.0	5.9	.18	1.9	22	97	1.7	12	163	236	8.0	43
1941-42	.2	.59	0	1.4	4.3	39	2.3	2	69	114	.6	23
1942-43	3.8	8.6	.19	.19	28	128	6.5	9	200	331	.9	34
1943-44	1.7	.83	0	.19	4.9	54	6.7	7	127	202	1.3	30
1944-45	2.9	2.1	0	5.0	15	68	4.6	11	123	200	2.4	29
1945-46	5.4	14	.34	5.2	46	128	4.9	14	274	372	20	66
1946-47	4.2	3.8	.14	5.2	24	153	7.4	20	313	468	12	76
1947-48	2.9	5.8	.25	6.5	18	106	5.3	15	259	353	8.6	59
1948-49	2.6	4.5	.28	9.2	23	85	1.1	13	167	205	1.0	30
1949-50	6.3	9.9	.43	5.8	41	184	13	34	458	571	19	106
1950-51	4.2	6.8	.32	2.6	36	120	4.7	17	253	347	13	68
1951-52	1.4	1.7	0	1.9	10	50	.6	5	83	141	.3	17
1952-53	5.6	11	.13	.56	22	74	2.1	13	162	141	1.1	32

Note - Periods used are for the year beginning April 1 and ending March 31.

Maximum Period of Deficient Discharge -- Useful analyses of low-flow characteristics may also include curves that indicate the maximum number of consecutive days during which the flow was less than a specified discharge. The maximum period of deficient discharge that may be expected for gaging stations in the Neuse River Basin for a 26-year period, in which the flow pattern was similar to that for 1927-53, is shown in figures contained in the report in preparation by the United States Geological Survey, referred to in the bibliography herein, and is listed in Table V. Again using the hypothetical industrial plant site, assume that it is necessary to know the maximum number of consecutive days, even in unusal years, when the flow will be less than 2.5 mgd. The curve, showing the maximum period of deficient discharge for Middle Creek near Clayton, shows that the flow of Middle Creek at the plant site may be less than 0.025 mgd per square mile, or 2.5 mgd, for not more than 40 consecutive days.

Storage Requirements -- Frequently during dry periods, streamflow is inadequate to meet the minimum requirements for many uses. Additional flow may be provided during such periods by the use of a storage reservoir. Storage of streamflow is often provided for municipal and industrial water supplies, power generation, supplements to low flows for waste dilution and navigation, flood control, and other uses.

The draft-storage curve is another means of studying the flow characteristics of streams. This curve shows the additional net storage required, disregarding evaporation, leakage, and dead storage, to maintain specific outflow rates. Storage curves for gaging stations at Flat River at Bahama, Neuse River near Clayton, Middle Creek near Clayton, and Little River near Princeton may be found in the report in preparation by the United States Geological Survey, referred to in the bibliography herein. Net storage for selected outflow rates and the average flow for all sites in the basin are listed in Table VI. In general, the storage curves were computed to 70 per cent of average flow, which is only slightly less than the ultimate practical development by storage.

As an example of the use of the storage curve, assume that the hypothetical industrial plant at a site adjacent to Middle Creek is to be expanded and that the total water requirement is to be 5 mgd. With this new water-supply criterion, the stream would be unable to meet the demand 6 per cent of the time and production stoppages or cutbacks would be more frequent and of greater proportions than before the expansion. If such a restricted schedule of operation would be uneconomical, it would be necessary to build a storage reservoir to maintain the flow required for continuous plant operation. The storage curve for the gaging station at Middle Creek near Clayton, referred to in the preceding paragraph, indicates that to meet the sustained demand of 5 mgd (or 0.05 mgd per square mile), a storage per square mile of 2.6 million gallons, or a total of 260 million gallons, would be required. To this volume must be added the amount of dead storage below the plant intake and an allowance for evaporation and leakage from the reservoir.

Flood Frequencies -- A State-wide flood-frequency study has recently been completed by the Geological Survey (Riggs 1955). Results of this study allow reliable frequency relations to be established for the Neuse River Basin. These relations for gaging stations at Neuse River near Northside, Neuse River near Clayton, Neuse River near Goldsboro, and Neuse River at Kinston may be found on flood-frequency curves

TABLE V--Maximum number of consecutive days when discharge was less than indicated in the Neuse River basin, 1927-53.

Gaging Station	Minimum daily flow of record (mgd sq. miles)	Discharge in million gallons per day per sq. mi.														
		0.006	0.001	0.002	0.003	0.005	0.010	0.015	0.020	0.030	0.040	0.050	0.060	0.1	0.2	0.45
Eno River at Hillsboro	0.0029					18	44	64	82	110	130	142	155	180	205	215
Flat River at Bahama	.0016				21	42	74	95	109	127	138	145	150	163	172	178
Diel Creek near Bahama				90	95	101	110	115	119	125	130	132	136	149	171	212
Flat River at dam near Bahama*			5	109	129	145	169	181	191	207	219	228	235	253	281	320
Neuse River near Northside	.0038					8	33	51	67	96	119	138	154	194	205	205
Lower Barton Creek nr. Bayleaf														25	144	222
Horse Creek near Wake Forest															122	182
Crabtree Creek near Raleigh							44	62	76	98	126	129	140	168	197	212
Mine Creek near Millbrook														41	157	213
Big Branch near Millbrook														50	162	212
Neuse River near Cleyton	.026									4	14	30	47	111	184	210
Swift Creek near McCullers							16	23	32	48	64	81	96	141	195	222
Middle Creek near Cleyton	.0032		1	3	4	7	16	23	32	48	65	81	95	141	195	220
Middle Creek near Smithfield				2	3	6	14	22	31	47	62	78	92	138	193	222
Black Creek near Four Oaks		58	66	80	90	104	127	142	153	168	179	186	191	206	220	230
Buck Swamp near Dudley								64	76	95	110	122	132	160	189	211
Little River near Princeton	.0028				2	7	22	36	48	70	86	100	112	147	185	212
Neuse River near Goldsboro	.024									11	28	46	63	125	183	212
Stony Creek at Goldsboro								36	48	69	86	100	112	147	185	212
Falling Creek at Falling Creek											76	91	103	141	183	211
Neuse River at Kinston	.030									3	19	35	51	103	171	218
Deep Run Creek at Deep Run														40	130	255
Moccasin Creek at Middlesex							16	23	32	48	64	80	95	142	197	227
Contentnea Creek near Wilson	.00055	37	58	84	95	107	118	121	124	127	129	132	135	145	167	215
Nahunta Swamp near Snow Hill								37	50	70	86	100	112	147	185	212
Contentnea Creek at Hookerton	.011							13	27	54	76	96	112	160	225	290
Core Creek near Fort Barnwell							66	83	96	116	131	142	151	173	197	215
Swift Creek near Vanceboro	.0021	28	31	38	44	52	68	81	92	109	125	139	151	190	242	297
Trent River near Trenton	.011							36	52	79	101	119	134	175	230	290

* Period of record (1927-53) unadjusted for regulation by Lake Michie and power plant or for diversion to City of Durham for municipal water supply.

**Period of record (1930-53) unadjusted for regulation by municipal reservoir and power plant or for diversion to City of Wilson for municipal water supply.

Table VI - Storage requirements in the Neuse River basin, April 1, 1928 to March 31, 1953

Gaging station	Drainage Area (Sq.miles)	Average discharge (mgd/sq mi)	Regulated flow, in mgd per square mile							
			0.01	0.02	0.03	0.05	0.1	0.15	0.2	0.45
			Storage required in million gallons per square mile							
Eno River at Hillsboro	66.5	0.638	0.17	0.87	1.8	4.3	12	22	34	120
Flat River at Bahama	150	.629	.45	1.9	3.5	7.0	16.	28	40	120
Dial Creek near Bahama	4.9	.579	.88	1.9	2.9	5.4	13	22	36	240
Flat River at dam near Bahama*	171	.601	1.1	2.4	4.0	7.5	18	30	44	140
Neuse River near Northside	526	.665	.07	.75	2.1	5.5	15	15	40	30
Lower Barton Creek near Bayleaf	13.2	.72					.33	3.1	9.7	82
Horse Creek near Wake Forest	21.0	.70						2.3	8.4	59
Crabtree Creek near Raleigh	97.8	.63	.07	.67	1.6	3.9	13	25	38	170
Mine Creek near Millbrook	8.75	.67					.17	3.6	11	94
Big Branch near Millbrook	3.90	.68					.45	3.6	12	110
Neuse River near Clayton	1,140	.696			.01	.55	5.8	14	24	100
Swift Creek near McCullers	53.9	.72		.33	.82	2.4	9.6	20	34	120
Middle Creek near Clayton	80.7	.729	.02	.15	.44	1.5	7.1	15	26	120
Middle Creek near Smithfield	124	.72	.07	.30	.72	2.2	9.4	20	34	160
Black Creek near Four Oaks	79.0	.73	1.5	3.7	6.2	12	25	38	53	170
Buck Swamp near Dudley	17.0	.68		.14	1.1	3.6	12	22	35	140
Little River near Princeton	229	.677	.13	.47	.99	2.5	9.0	15	32	140
Neuse River near Goldsboro	2,390	.659			.04	.62	5.5	11	26	100
Stony Creek at Goldsboro	21.0	.68		.17	.78	2.5	9.4	20	33	130
Falling Creek at Falling Creek	45.4	.67					8.4	18	29	120
Neuse River at Kinston	2,690	.674				.33	3.6	10	20	88
Deep Run Creek at Deep Run	6.1	.74					.20	2.6	8.7	65
Moccasin Creek near Middlesex	28.2	.73		.35	.86	2.5	9.6	20	32	120
Contentnea Creek near Wilson**	236	.646	.69	1.8	3.2	6.5	17	30	45	140
Nahunta Swamp near Snow Hill	97.1	.67		.20	.78	2.4	9.2	19	30	130
Contentnea Creek at Hookerton	789	.613		.11	.42	1.8	9.9	21	36	180
Core Creek near Fort Barnwell	59.2	.65		.77	2.1	5.2	16	29	46	180
Swift Creek near Vanceboro	182	.59	.49	1.3	2.4	5.2	16	30	48	220
Trent River near Trenton	168	.61		.24	.86	3.0	12	24	36	170

* Period of record (1927-53) unadjusted for regulation by Lake Michie and power Plant or for diversion to City of Durham for municipal water supply.

**Period of record (1930-53) unadjusted for regulation by municipal reservoir and power plant or for diversion to City of Wilson for municipal water supply.

contained in the report in preparation by the Geological Survey, referred to in the bibliography herein.

Each frequency curve shows the average interval, in years, between floods that equal or exceed a given elevation. This does not mean that floods occur with any regularity; the recurrence intervals are average values only. It would be possible to have two floods of 50-year recurrence-interval in successive years or in the same year.

Although frequency curves give average recurrence intervals only, they have much practical utility. For example, the frequency curve might be used to determine the elevation of a building in the flood plain of a river such that flood water would reach it, on the average, only once in 50 years. Similarly, the average frequency of flooding of a road fill could be determined from the curve.

However, there are problems in which flood frequencies at certain times of the year are needed. To meet this need, summer and winter flood-frequency curves are presented. The summer period extends from May 1 to October 31, and the winter period is the remaining 6 months of the year. These curves may be used to determine the probability of occurrence of a given flood in the selected season.

For example, suppose that a construction project is proposed for a location near the Neuse River near Clayton at an elevation of 145 feet above mean sea level. By use of the frequency relations for the gaging station at Neuse River near Clayton, referred to in the first paragraph under "Flood Frequencies" above, it may be determined that the recurrence interval of winter floods, reaching that height, is 10.8 years. This means that there is about a 1 to 11 chance that, if the work is done in a winter season, it will be interrupted by flooding. Similarly from the curve for summer floods, it may be determined that the chances are about 1 in 5 that it will be interrupted if the work is done in a summer season. In the example cited, the probability of flooding is greater in summer than in winter. On the other hand, if the elevation at the proposed project site is lower than 141 feet above mean sea level, the frequency relations for the gaging station at Neuse River near Clayton indicate that the probability of flooding in summer is less than in winter but, of course, much greater than at higher elevations. The curve for summer floods could also be used to evaluate the risk of farming on a flood plain or of putting the flood plain to other seasonal use.

In general, the curve for frequency of all floods should be used in design of structures which are made to last for several years, and the seasonal curves to evaluate the risk of flooding in a single season. The design of dam spillways or other structures, failure of which will result in considerable damage or loss of life downstream, is usually based on analyses involving maximum known floods rather than a flood of a specified frequency.

Quality of Surface Water -- A program to determine the chemical character of the waters of the Neuse River was first undertaken in 1906. Daily samples for chemical analyses were collected from the Neuse River near Raleigh for a period of one year. Additional data were obtained during the period November 1932 to June 1933. A continuing, cooperative program to determine the chemical quality of surface waters was established between the U. S.

Geological Survey and the North Carolina Department of Conservation and Development in 1943. Six daily and one monthly sampling stations for chemical quality studies have been in operation on streams in the Neuse River Basin for at least one year since 1943. In addition to the daily and monthly sampling stations, samples for chemical analyses have been collected intermittently at all complete-record and partial-record gaging stations within the basin. The mineral constituents and physical properties that have a bearing on most uses of surface water are summarized for each daily sampling location in Table VII. Figures, showing the average chemical composition of the dissolved solids of the surface water at each of the daily sampling stations in the basin during the period 1943-54, the relation of hardness to dissolved solids in surface waters in the basin, and the realtion between streamflow and selected chemical and physical characteristics of Neuse River near Clayton, 1943-44, may be found in the report in preparation by the U. S. Geological survey, referred to in the bibliography herein.

The highest color occurred during November. The hardness varied only slightly with streamflow, whereas the dissolved solids fluctuated with the flow, being highest during October through most of December and during the latter part of summer when the streamflow was the lowest. The highest temperature of the water occurred during June, July, and a few days in August and September. Smithfield, about 10 miles below the Clayton Station, uses Neuse River for its source of public water supply. Inasmuch as there is no appreciable amount of inflow between Clayton and Smithfield, the chemical and physical characteristics of the waters of the Neuse River at Smithfield can be considered to be similar to that near Clayton.

Except for excessive quantities of iron and high color the chemical quality of the water from Little River is excellent. The dissolved solids ranged from 44 to 56 ppm, and hardness ranged from 9 to 22 ppm.

The water from Contentnea Creek would generally be suitable for an industrial or public water supply on the basis of the mineral content. The uniformity of the dissolved solids and low hardness make it highly desirable for most uses. (See Table VII). Color ranged from 15 to 45 units during the 1950 water year. Contentnea Creek drains several swamp areas which contribute rather highly colored waters to the main stream.

Several swamp streams flowing into Swift Creek contribute to the high color of the water (23 to 55 units). Objectionable amounts of iron occurred during the period of record, October 1951 to September 1952. Contamination from salt-water intrusion is likely to occur in the lower part of the stream.

The hardness of waters from Trent River near Trenton is greater than from the other streams in the basin. The dissolved solids ranged from 59 to 128 ppm. The waters are highly colored (23 to 110 units) because of inflow from many swamp streams.

Salt-water intrusion in the lower region of the Neuse River Basin has adversely affected the chemical quality of the surface waters in the area. The chemical quality of surface waters varies with the tide

and the extent of salt-water intrusion. At the mouth of the Neuse River, the salinity is very high, at times as much as 10,000 ppm of dissolved solids. The salinity decreases upstream until the limit of salt-water intrusion is reached. Adequate data are not available to indicate the upstream limit of intrusion.

Table VII -- Summary of chemical analyses of water from streams in the Neuse River basin

Period of record	Neuse River near Clayton October 1943 to September 1944		
	Maximum	Minimum	Average
Discharge (cfs)	8,680	92	1,114
Silica (SiO_2)	23	8.5	15
Iron (Fe)	.30	.02	.06
Calcium (Ca)	6.7	3.3	5.0
Magnesium (Mg)	2.4	1.3	1.8
Sodium (Na))			
Potassium (K))	18	4.4	10
Bicarbonate (HCO_3)	44	11	27
Sulfate (SO_4)	8.4	3.8	5.4
Chloride (Cl)	14	3.5	7.6
Fluoride (F)	.1	.0	.1
Nitrate (NO_3)	8.5	.4	3.4
Dissolved solids (residue on evaporation at 180°C)	101	47	70
Hardness as $CaCO_3$	26	14	20
Color	42	8	20
pH	--	--	--
Specific conductance (micromhos at 25° C)	--	--	--

Table VII -- Continued

Period of record	Neuse River near Goldsboro October 1948 to September 1949		
	Maximum	Minimum	Average
Discharge (cfs)	13,000	605	3,674
Silica (SiO_2)	20	7.3	11
Iron (Fe)	.28	.02	.07
Calcium (Ca)	4.9	2.8	3.7
Magnesium (Mg)	2.2	1.0	1.5
Sodium (Na))			
Potassium (K))	8.9	2.8	5.8
Bicarbonate (HCO_3)	25	12	18
Sulfate (SO_4)	7.9	3.7	5.0
Chloride (Cl)	6.9	3.2	5.4
Fluoride (F)	.2	.0	.1
Nitrate (NO_3)	1.6	.1	.7
Dissolved solids (residue on evaporation at 180°C)	65	43	52
Hardness as $CaCO_3$	21	11	15
Color	45	17	28
pH	6.8	5.9	6.4
Specific conductance (micromhos at 25° C)	77.4	41.8	60.5

Table VII -- Continued

Neuse River at Kinston			
Period of record	October 1949 to September 1950		
	Maximum	Minimum	Average
Discharge (cfs)	7,620	532	2,002
Silica (SiO_2)	16	5.3	12
Iron (Fe)	.42	.02	.15
Calcium (Ca)	8.0	3.6	5.3
Magnesium (Mg)	2.4	1.1	1.7
Sodium (Na))			
Potassium (K))	18	4.0	8.4
Bicarbonate (HCO_3)	54	13	24
Sulfate (SO_4)	12	4.6	6.5
Chloride (Cl)	13	4.1	7.5
Fluoride (F)	.3	.0	.1
Nitrate (NO_3)	2.6	.3	1.2
Dissolved solids (residue on evaporation at 180° C)	84	52	64
Hardness as $CaCO_3$	30	14	20
Color	50	10	21
pH	7.3	6.2	6.6
Specific conductance (micromhos at 25° C)	136	50.1	84.0

Table VII -- Continued

Contentnea Creek at Hookerton			
Period of record	October 1949 to September 1950		
	Maximum	Minimum	Average
Discharge (cfs)	1,500	97	461
Silica (SiO_2)	14	6.0	10
Iron (Fe)	.60	.01	.13
Calcium (Ca)	4.4	3.0	3.7
Magnesium (Mg)	1.6	1.0	1.3
Sodium (Na))			
Potassium (K))	9.1	4.0	6.3
Bicarbonate (HCO_3)	19	9	13
Sulfate (SO_4)	8.3	4.4	6.0
Chloride (Cl)	9.2	4.6	6.7
Fluoride (F)	.4	.0	.2
Nitrate (NO_3)	2.3	.1	1.1
Dissolved solids (residue on evaporation at 180° C)	63	45	53
Hardness as $CaCO_3$	17	12	15
Color	45	15	25
pH	6.6	5.8	6.3
Specific conductance (micromhos at 25° C)	77.5	53.1	62.3

Table VII -- Continued

Period of record	Swift Creek near Vanceboro October 1951 to September 1952		
	Maximum	Minimum	Average
Discharge (cfs)	1,330	1.6	132
Silica (SiO_2)	14	7.1	10
Iron (Fe)	.69	.05	.16
Calcium (Ca)	23	6.9	12
Magnesium (Mg)	4.2	1.2	1.9
Sodium (Na))			
Potassium (K))	31	4.5	12
Bicarbonate (HCO_3)	77	9	31
Sulfate (SO_4)	19	10	14
Chloride (Cl)	43	7.6	17
Fluoride	.2	.0	.1
Nitrate (NO_3)	2.6	.2	1.2
Dissolved solids (residue on evaporation at 180°C)	169	66	99
Hardness as $CaCO_3$	70	24	38
Color	55	23	36
pH	7.2	6.1	6.7
Specific conductance (micromhos at 25° C)	291	81.9	149

Table VII -- Continued

Period of record	Trent River near Trenton October 1951 to September 1953					
	Maximum		Minimum		Average	
	51-52	52-53	51-52	52-53	51-52	52-53
Discharge (cfs)	1,050	1,600	3.1	4.6	117	97.5
Silica (SiO_2)	9.4	9.4	3.4	4.4	6.7	7.0
Iron (fe)	.38	.30	.03	.02	.17	.10
Calcium (Ca)	36	41	7.4	8.8	20	24
Magnesium (Mg)	2.4	2.5	1.0	.3	1.6	1.5
Sodium (Na))						
Potassium (K))	12	11	2.0	1.2	4.2	4.3
Bicarbonate (HCO_3)	106	122	18	18	55	61
Sulfate (SO_4)	18	33	3.8	5.6	8.9	13
Chloride (Cl)	8.8	9.5	5.5	4.2	6.8	7.9
Fluoride (F)	.1	.1	.0	.0	.0	.0
Nitrate (NO_3)	1.6	2.0	.2	.1	.6	.7
Dissolved solids (residue on evaporation at 180° C)	128	143	59	69	95	108
Hardness as $CaCO_3$	99	112	23	23	56	65
Color	110	120	16	14	65	60
pH	7.6	7.4	6.3	6.4	6.9	6.9
Specific conductance (micromhos at 25° C)	223	245	60.7	49.1	135	155

CHAPTER VIII - - GROUND WATER

Occurrence of Ground Water -- In the Coastal Plain formations of the Neuse River Basin, there are many alternating layers of permeable sand and impermeable clay, sloping southeastward beneath the surface. Water moves through the sand easily; its movement through the clay, however, is retarded. Water entering the sand at higher elevations exerts a considerable pressure on the water already confined in the sand, and this pressure forces water upward through a well. Water under pressure of this kind is said to be under artesian conditions, and a well in which the water rises above the base of the overlying, confining bed is known as an artesian well. At many places in the basin, there is sufficient artesian pressure to cause wells to flow at the surface.

As water is removed from an aquifer, it must be replaced, or the water stored in the aquifer will be exhausted. Precipitation is the source of this recharge water, replenishing the underground water throughout the basin, either by direct downward seepage under water-table conditions or by percolation into the artesian aquifers, where they crop out at the surface or can otherwise receive water. If yields are to be sustained indefinitely, withdrawal of water cannot exceed average recharge; in addition, it cannot induce the encroachment of water of poor quality.

Generally, water first entering the ground tends to move toward nearby streams and discharge into them. If water levels are lowered sufficiently in wells which penetrate permeable strata near these streams, a reverse flow may occur, and the ground-water reservoir will receive recharge from the streams. Recharge of this type, known as induced infiltration, is important at many places in the United States. It does not, however, take place on any significant scale in the Neuse River Basin.

Pumping lowers the water pressure at a well and establishes a hydraulic gradient, which allows water to flow toward the well. As pumping continues to lower the water level in the well, the influence of the gradient extends farther away, and water may be intercepted that ordinarily would discharge elsewhere. If the discharge thus salvaged is sufficient, water levels will eventually stabilize, and large yields may be sustained. Conditions of this type seem to exist near Kinston as a result of heavy pumping at a large textile plant there.

In the Neuse River Basin, most ground-water supplies are obtained from wells. Most springs have poor yields and are usually inaccessible, so that it is difficult and expensive to develop water supplies from them. A properly located and properly constructed well, however, is a dependable and economical source of water. Wells are the common source of water for rural domestic use, and many towns also have wells for their supplies.

Geology -- The amount and availability of ground water depend upon a number of geologic factors, such as the type of rock, the way the grains are held together, and the way the rocks are fractured. A brief description of the rock formations of the Neuse River Basin may help the reader to understand the ground-water conditions better. In general, the rocks of the Piedmont are dense slates, granites, and similar rocks. There are also some compact shales and sandstones. These rocks are exposed in half of the basin and slope beneath the Coastal Plain rocks to the southeast.

The rocks of the Coastal Plain are generally unconsolidated sand and clay, and partly consolidated limestone. These strata slope eastward at a slightly greater rate than does the land surface, and, therefore, are buried progressively deeper toward the coast. These formations increase in total thickness from a featheredge in the Fall Zone to a probable maximum of 4,000 feet along the coast.

Rocks of the Piedmont and Fall Zone -- The Volcanic Slate Series is a series in interbedded tuffs, breccias, lava flows, shales, slates and schists, all called slate rocks for convenience. These rocks, which are prevailingly gray-to-greenish blue in color with associated quartz veins and diabase dikes, underlie the northwestermost part of the basin. Generally, these rocks are tipped on end and trend northeast. They are predominantly acidic in composition. The iron minerals, however, have stained the weathered soil-zone a brown or deep red color. Jointing and shearing are common features within several hundred feet of the surface. The total thickness of the slate rocks is unknown but is many thousands of feet. These rocks, probably of early Paleozoic age, are found chiefly in the northwestern end of the Neuse River Basin in the vicinity of Hillsboro, and in the Fall Zone in the area around Middlesex and Smithfield.

The granites, especially well-exposed in the vicinity of Wendell, are gray or pink, medium-to-coarse-grained, massive-to-well-fractured rocks. An extensive body of fine-grained, generally massive gneiss, composed chiefly of quartz, mica, and feldspar, is found around Raleigh and Wake Forest. This rock is believed to consist of metamorphosed sediments. It is generally known as granite, however, and is, therefore, included herein with the granites. Banding in the gneisses trends northwest. Because of a thick soil-zone, the areal relations between these rocks and the granites are obscure. All of them extend downward to a great depth.

The consolidated shales, claystones, sandstones, conglomerates, and arkoses of the Upper Triassic Newark group, all called shale rocks for convenience, occupy a northeast-trending graben to a depth of 8,000 to 10,000 feet. Beneath a thin, reddish-brown soil-zone, the rocks, chiefly shale, are compact and well-cemented. Many faults and disbase dikes, however, cut the gently-to-moderately-sloping strata. These rocks, exposed north and east of Durham, contain some thin beds of coal which are not mined.

Rocks of the Coastal Plain -- The basal formation of the Coastal Plain is the Tuscalooasa formation of late Cretaceous age. It consists of lenticular gray, yellow, red, and tan clay, sand clay, and some gravel. The beds increase in thickness from a featheredge in the middle part of the Fall Zone to about 100 feet at Goldsboro and to about 560 feet at Morehead City. They dip southeastward at about 15 feet per mile in much of the basin. This slope, however, increases near the coast. Somewhere down the dip, similar sediments of early Cretaceous age may intervene between the Tuscaloosa formation and bedrock. These sediments, if present, would be hydrologically similar to the Tuscaloosa.

Dark-gray-to-black, laminated, lignitic clays alternate with fine-grained, gray sands in these Upper Cretaceous strata which overlie the Tuscaloosa formation. The Snow Hill marl member, at the top of the Black Creek formation, is a fossiliferous, glauconitic, sandy marl. The formation dips southeastward, beginning at Goldsboro, and increases in thickness to about 600 feet at the coast.

The Peedee-formation of Upper Cretaceous age consists of interbedded clay, sand, marl, and limestone, which dip southeastward at about 10 to 25 feet per mile, increasing in thickness from a thin edge near La Grange to a maximum of 600 feet. The formation is very fossiliferous and contains much glauconite.

The Castle Hayne limestone is a light-to-dark gray, poorly-to-well-consolidated limestone, and sandy limestone or marl, containing abundant shells. The formation has a slight, southeastward dip, and increases in thickness from a featheredge near Kinston to more than 250 feet along the coast.

The Yorktown formation is an extensive, fossiliferous, upper Miocene formation, covering much of the northern half of the basin and increasing in thickness from a few feet near Wilson to more than 150 feet near Cherry Point. In lithology, the formation varies from a sticky, blue clay to a loose, shell marl.

Surficial sands mantle much of the Coastal Plain. They consist of a series of thin beds of sand and clayey sand, which, in part, are derived from underlying formations and which include some sand, clay, and shell beds of Pleistocene age. The surficial beds probably do not exceed 30 feet in thickness except along the coast, where well-developed sand dunes are found.

Ground-Water Provinces -- Ground-water conditions are not uniform throughout the Neuse River Basin. Several ground-water provinces have been differentiated because of significant differences in character and structure of the rocks, yield of wells, and quality of water. The aquifers in each province consist of one or more bodies of rock having similar hydrologic properties. Although these aquifers are distinctive in most places, it is evident that they lose some of their identity where they adjoin other aquifers. The quantity and quality of water that can be obtained from each of the water-bearing units varies with the type of well and its location and depth.

Piedmont Province -- The Piedmont ground water consists of the area underlain by rocks described as the slate rocks, granites, and shale rocks. Together, these rocks form the poorest aquifer in the Neuse River Basin.

In general, the slate rocks and granites are massive, crystalline rocks whose grains are intergrown or held together by molecular attraction. Pore space is negligible, and usable water is found only along bedding planes, along planes of cleavage and schistosity, and in zones where fracturing and solution have occurred.

Many of the openings in the slate rocks and granites are the result of weathering processes which operate close to the earth's surface. A well will generally encounter fewer openings as it is deepened, so that it is usually not worth while to drill wells to great depths. Coarse-textured rocks generally are relatively good water-producers, because weathering or fracturing will tend to open larger spaces in them than in fine-textured rocks.

Much water is stored in the weathered, or decayed, rock that lies immediately below the surface. This water will recharge underlying fractures as wells are pumped, and good yields may result if the weathered zone is thick and permeable.

The intrusion of dikes and the growth of mineral veins may have caused fracturing in the surrounding rocks. Quartz veins are common in the slates and granites, and, because quartz is a brittle mineral, many large openings have developed in the veins as a result of earth movements. A well, drilled into a quartz vein or into the fractured zone near a dike, may yield a large amount of water.

Fractured zones usually are less resistant to erosion than are the relatively unfractured rocks, allowing valleys and other low places to develop. Thus, a well drilled in low places has a greater chance of intersecting openings than a well on high ground; also, the natural drainage of ground water is toward valleys. Records of wells in the slates and granites indicate that most wells drilled in valleys are much more productive than wells drilled on hills.

The shale rocks are chiefly shales or claystones which have been so compacted and cemented that permeability is low. Ground water cannot move rapidly through the minute pores, most of the movement being through fractures and along bedding planes. These shales commonly yield less water than the granites and slates. The sandstones are somewhat better producers.

Many wells in the shales have fairly good yields at first. They become much less productive after a short time. Probably, water in the pores near such wells is withdrawn quickly. The movement of recharge water from farther away, however, is too slow to sustain the initial rate of production.

Depth and Yield of Wells -- Throughout the Piedmont Province, most domestic supplies are obtained from dug or bored wells which are generally carried down to hard rock. Such wells average about 40 feet in depth and furnish enough water for household use, except in very dry summers. A drilled well, located at a favorable place, generally will yield more water, inasmuch as it can be made deeper than the dug wells. Because most of the usable ground water occurs in fractures which are formed near the surface, it is generally uneconomical to drill wells to depths greater than 300 feet. Because no sand or other loose material is ordinarily found in these rocks to fill up the well, an open-end well is usually satisfactory.

In the slate rocks and granites, the best wells may yield as much as 50 gallons per minute. Wells yielding more than 25 gallons per minute are not common. The average yield of wells drilled in the shale rocks is only 10 to 15 gallons per minute. As much as 30 gallons per minute may be obtained from the more permeable sandstones or from fractures zones near dikes.

Fall Zone Province -- Slate rocks and parts of the Tuscaloosa, Black Creek, and Yorktown formations are included in the Fall Zone Province. The rocks of this province are generally better water-producers than those of the Piedmont Province, and are not as good water-producers as the Coastal Plain aquifers farther to the southeast.

The slate rocks in the western part of the Fall Zone Province are similar to those in the westernmost part of the Piedmont Province. The yield to wells in the former, however, is generally larger, the rocks apparently being more schistose and more highly fractured. The Coastal Plain beds are chiefly unconsolidated clays or sandy clays of low permeability. They are rarely greater in thickness than 100 feet.

Depth and Yield of Wells -- Small supplies for rural domestic use are generally obtained from dug or bored wells. In the Coastal Plain, however, driven wells, or well points, are also common. Such wells are rarely deeper than 50 feet.

Larger supplies, for municipal or industrial use, may be obtained if wells are properly located and constructed. Where slate rocks are exposed, wells should be located in the manner already described for the Piedmont Province. Open-end wells are satisfactory and generally need be no deeper than 300 feet.

In the Coastal Plain section of this province, good yields are obtained if sand strata are encountered in drilling. Maximum yields are generally obtained if wells are drilled through the Coastal Plain Strata and into the underlying slates. If sand strata or other loose sediments are penetrated, a screen will prevent the entrance of such material into the well but will allow the water to enter and be added to the total supply. Open-end wells are satisfactory if they end in firm material. Most of the available water will be obtained within 300 feet of the surface.

Wells drilled in favorable places may yield 50 to 200 gallons per minute. The best wells in this province have produced as much as 200 gallons per minute. Such yields generally decline over a period of several years, however, the permeability of the rocks not being high enough to provide sufficient recharge to sustain heavy pumping.

Cretaceous Sand Province -- The Black Creek and Peedee formations of Upper Cretaceous age are the chief aquifers in the Cretaceous Sand Province. Fine-to-medium-grained sands alternate with beds of clay throughout the entire thickness of the Coastal Plain Strata. Clay of the Yorktown formation is found near the surface in the northeast half of the province. Only small domestic supplies can be obtained from these sources.

The sands that lie at greater depth are recharged from precipitation on the outcrops to the northwest and constitute excellent artesian aquifers. The sands are generally clean, and permeability is good.

Depth and Yield of Wells -- Because water is withdrawn from beds of sand which alternate with layers of clay, a well is drilled through one or more sand beds, depending on the amount of water required. Wells range in depth, therefore, from 100 to more than 600 feet, the aggregate yields generally increasing with depth.

It is necessary to install a screen or slotted pipe in each sand zone to allow water to enter the well. If only one sand layer is utilized, a maximum yield of 100 gallons per minute may be expected. Properly developed wells, getting water from several sand beds, are capable of much larger yields. Yields in excess of 500 gallons per minute have been obtained from gravel-walled wells in this province. Properly screened and developed wells without gravel walls, however, may give comparable results.

Tertiary Limestone Province -- This province consists of the shell limestones and interbedded sands of the Castle Hayne and Yorktown formations. There are some clay beds or other zones of low permeability in these strata that allow excellent artesian conditions to develop. The limestones owe their exceptional permeability to the removal, by percolating waters, of much soluble material, thereby enlarging the openings and facilitating the movement of ground water.

Depth and Yield of Wells -- In most places, the limestone is consolidated enough to allow the use of open-end wells. There are many places, however, where the aquifer is unconsolidated and gravel-walled wells or other screened wells are profitable. Wells are generally drilled to obtain water from several permeable layers, so that depths range from 100 to more than 300 feet, depending on the quantity of water desired and the thickness of the fresh-water body. Yields of more than 500 gallons per minute are generally obtained from properly constructed wells in the Tertiary Limestone Province.

Composite Limestone-Sand Province -- This province is an intermediate zone in which adequate ground-water supplies may be obtained from the limestones of Tertiary age near the surface or from sands of Cretaceous age beneath.

Depth and Yield of Wells -- Generally, the shell limestone of Tertiary age is less than 100 feet thick, and only shallow wells obtain water from this source. Deeper wells may obtain water solely from the sands of Cretaceous age or may utilize the limestone aquifer also. Wells may, therefore, range in depth from less than 100 feet to more than 600 feet, the maximum depth being limited by the presence of salt water.

Yields and types of wells are comparable to those in the adjoining ground-water provinces. Most wells, yielding more than 500 gallons per minute, obtain water from both aquifers.

Quality of Water -- The quality of the ground water in the Neuse River Basin is summarized in Table I.

The rocks in the Piedmont and Fall Zone Provinces generally yield water of similar chemical character, and the analyses of water from both provinces are summarized together. Sixty-eight water samples ranged from 43 to 1,460 parts per million (ppm) in dissolved-solids content, the median being 108 ppm. Sodium bicarbonate predominates. The hardness ranged from 10 to 750 ppm, and the median was 46 ppm. The iron content ranged from essentially zero to 17 ppm. Of 70 samples analyzed for iron content, 48 contained less than 1.0 ppm, 37 of them less than 0.30 ppm, and 22 contained more than 1.0 ppm. Sixty-eight samples ranged from 2.5 to 815 ppm in chloride, and 72 samples ranged from 0.6 to 179 ppm in sulfate content. These samples seldom exceeded 20 and 17 ppm, respectively. Analyses, showing very hard water and much dissolved mineral matter, are generally of water from the shale rocks. Temperatures range from 60 to 63 degrees F. for water from the slate rocks and granites, and from 58 to 66 degrees F. for water from the shale rocks.

Generally, the water from the Cretaceous Sand Province is of excellent chemical quality, suitable for most purposes with little or no treatment. Water from shallow wells in the southeastern half of the province may be hard. Deeper water, however, is soft and resembles that from

TABLE I--Summary of analyses of ground waters in the Neuse River Basin
(Chemical constituents in parts per million)

Ground-water provinces	Piedmont and Fall Zone Province				Cretaceous Sand Province				Tertiary Limestone Province			
Constituent	No. of samples analyzed	Median	Minimum	Maximum	No. of samples analyzed	Median	Minimum	Maximum	No. of samples analyzed	Median	Minimum	Maximum
Silica (SiO_2)	68	32	4.9	56	61	18	4.0	34	16	22	13	53
Iron (Fe)	70	.32	.00	17	72	.38	.03	7.6	16	2.0	.07	5.2
Calcium (Ca)	68	9.8	2.0	182	62	8.3	.3	103	16	79	50	104
Magnesium (Mg)	68	3.8	.7	72	62	2.7	.3	9.6	16	2.7	1.7	30
Sodium (Na)) Potassium (K))	68	11	3.6	261	62	15	3.6	301	16	6.4	1.5	113
Bicarbonate (HCO_3)	72	59	1	472	89	143	0	388	33	350	172	458
Sulfate (SO_4)	72	4.7	.6	179	89	4.7	.4	129	32	3.0	.2	60
Chloride (Cl)	72	4.5	2.5	815	89	5.9	2.8	190	37	9.0	3.8	760
Fluoride (F)	70	.1	.0	1.7	73	.2	.0	1.1	24	.2	.0	1.0
Nitrate (NO_3)	70	.4	.0	27	66	.3	.0	30	18	.1	.0	.6
Dissolved solids (residue on evaporation at 180° C)	68	108	43	1,460	62	148	41	826	16	253	190	484
Hardness as $CaCO_3$	71	46	10	750	89	42	2	283	35	219	110	391
Color	67	3	0	28	56	4	0	37	14	5	2	18
pH	68	6.7	5.4	8.7	67	7.3	4.6	8.4	24	7.2	6.9	7.6
Specific conductance (micromhos at 25° C)	41	180	52.7	2,850	45	261	41.9	550	22	435	316	3,210

the northwestern half of the province. Hardness in water from the Cretaceous Sand Province generally ranges from 15 to 125 ppm and dissolved solids from 73 to 189 ppm. Sodium bicarbonate predominates. Iron in 72 water samples from wells in this province ranged from 0.03 to 7.6 ppm, the median being 0.38 ppm.

The Tertiary Limestone Province yields water in which calcium bicarbonate predominates and which has a hardness ranging from 110 to 391 ppm. Ground water sampled in the province contained 0.07 to 5.2 ppm of iron. In 37 water samples, the chloride content ranged from 3.8 to 760 ppm, the median being 9.0 ppm.

Ground water in the Composite Limestone-Sand Province resembles that from the Cretaceous Sand and Tertiary Limestone Provinces, depending on source.

Figures showing chemical character of ground water in the Neuse River Basin may be found in the United States Geological Survey report referred to in the bibliography herein.

Water Levels -- Water levels in wells reflect the fluctuations of the water table. Although precipitation is the source of ground water, water levels in the Neuse River Basin are not highest during the summer when rainfall is greatest. Generally, the water table is at its highest level in the spring. As crops and other vegetation begin to remove water from the soil, a deficiency in soil moisture develops. Rainfall reaching the ground must make up this deficiency before any can reach the water table. Because high summer-temperatures cause high rates of evaporation, the ground-water reservoir is recharged during the summer only when rainfall is heavy or prolonged. Summer storms sometimes produce very heavy rains which cannot be quickly absorbed by the soil, and surface runoff is often great. During the summer, withdrawal of water for human use is also much greater, whether for recreation, irrigation, or other uses.

It seems obvious that these few factors -- high rate of evaporation and transpiration, large withdrawals, and the brevity of summer storms -- either remove much ground water from storage or prevent effective ground-water recharge, so that water levels reach their lowest points at the end of the growing season.

During fall, winter, and early spring, fewer demands are made upon the ground-water reservoirs. Withdrawal is much less during these season, vegetation is removing much moisture from the soil, evaporation is at its lowest rate, and the winter rains are comparatively prolonged. Large amounts of precipitation percolate into the zone of saturation, and ground-water levels rise to their highest stage of the year.

A comparison of a hydrograph of one observation well in the Neuse River Basin with climatic data may be found in the United States Geological Survey report referred to in the bibliography herein. This illustration shows that water levels usually rise soon after a rainfall and then decline slowly thereafter.

Sometimes, drainage works are constructed to lower the water table permanently in swamps and meadow lands so that more valuable crops may be raised. In the Neuse River Basin, such drainage projects have been effective

locally. They have not been extensive enough, as yet, to lower water tables over wide areas.

There is often some concern about falling water levels toward the end of the growing season when water levels are at their lowest stage of the year. There is seldom any occasion for concern where the water table in the spring is at the highest point of its cycle. Thus, it may not be generally realized that the water table at any given time of year differs little from its stage at the same time in previous years. Periods of several years of persistently dry or persistently wet weather cause temporary downward or upward trends from year to year. However, where the ground water is not pumped heavily or otherwise discharged artificially (as through drainage ditches), these trends are not permanent, and, over a long period of years, the average ground-water levels change little.

CHAPTER IX - - ABATEMENT OF STREAM POLLUTION

Status of Pollution Studies - - During the summer of 1954, the State Stream Sanitation Committee initiated comprehensive studies in the Neuse River Basin. These studies included investigation of water and land uses, sources of pollution, and determinations for physical, biochemical, and bacteriological characteristics of water taken from the streams. As of March 11, 1955, studies had been completed on that portion of the basin extending from the source to Milburnie. This work will be continued and completed during the summer of 1955. Following the completion of the study, a comprehensive report will be prepared, with public hearings and classifications to take place by the end of 1956.

Points of Significant Pollution - - Table I lists 43 points of significant pollution that serve an estimated population of 230,000 and discharge approximately 23.5 mgd of domestic and industrial waste into the streams of this basin. Industries, in most cases, are served by municipal systems; however, Table II lists industries with private systems that discharge approximately 207 mgd of water into the stream.

TABLE I
POINTS OF SIGNIFICANT POLLUTION IN NEUSE RIVER BASIN
Domestic Sewerage Systems
MARCH 1955

Location	Pop. 1950	Est. Pop. Served	Owner-ship	Est. Gals. Waste M.G.D.	Kind of Waste	Type of Treatment	Receiving Stream
Apex	1,065	662	M	0.062	D.S.	Primary	Middle Creek
Ayden	2,282	1,820	M	0.126	D.S.	Primary	Swift Creek
Bailey	743	520	M	0.045	D.S.	Secondary	Beaverdam Creek
Benson	2,102	1,630	M	0.110	D.S.	Primary	Driving Branch
Cary	1,446	1,476	M	0.140	D.S. & I.W.	Secondary	Cole Branch
Caswell Training School	- - -	2,100	I	0.30	D.S. & I.W.	None	Neuse River
Cherry Point Marine Air Base	- - - - - - -No	Information	Available	- - - -	- - - - - -	- - -	Neuse River
Clayton	2,229	1,830	M	0.071	D.S.	None	Little Creek
Creedmoor	852	408	M	0.033	D.S.	Primary	Ledge & Robertson Cr.
Durham	71,311	39,000	M	3.4	D.S. & I.W.	Secondary	Elerbe Cr. & Neuse R.
Farmville	2,942	2,400	M	0.20	D.S.	Primary	Little Contentnea Cr.
Fountain	451	350	M	0.027	D.S.	Secondary	Black Swamp
Fremont	1,395	990	M	0.072	D.S.	Secondary	Aycock Swamp
Goldsboro	21,454	20,000	M	1.4	D.S. & I.W.	None	Neuse River
Grifton	510	400	M	0.024	D.S.	Primary	Contentnea Creek
Havelock Park	- - -	420	P	0.029	D.S.	Primary	Neuse River
Hillsboro	1,329	500	M	0.039	D.S.	None	Eno River
Hookerton	253	250	M	0.015	D.S.	None	Contentnea Cr.
Kenly	1,129	1,100	M	0.073	D.S.	Secondary	Little Buffalo Cr.
Kennedy Homes - Kinston	- - -	200	I	0.02	D.S. & I.W.	None	Falling Creek
Kinston	18,336	18,000	M	1.35	D.S. & I.W.	None	Neuse River
La Grange	1,852	1,280	M	0.089	D.S.	Primary	Bear Creek
Lucama	405	334	M	0.025	D.S.	Primary	Creek to Contentnea Cr.
Middlesex	446	400	M	0.020	D.S.	Primary	Creek to Contentnea Cr.
New Bern	15,812	9,800	M	1.50	D.S. & I.W.	None	Neuse River
Pikeville	464	425	M	0.032	D.S.	Primary	Creek to Contentnea Cr.
Princeton	608	420	M	0.025	D.S.	Primary	Creek to Neuse River
Raleigh	65,679	75,000	M	8.6	D.S. & I.W.	None*	Crabtree & Walnut Creeks
Raleigh - Durham Airport	- - -	100	RDAA	0.02	D.S.	Secondary	- - - - - - - - - - -
Selma	2,639	2,400	M	0.27	D.S. & I.W.	Primary	Mill Swamp

TABLE I (CONTINUED)
POINTS OF SIGNIFICANT POLLUTION IN NEUSE RIVER BASIN
Domestic Sewerage Systems
MARCH 1955

Location	Pop. 1950	Est. Pop. Served	Owner-ship	Est. Gals. Waste M.G.D.	Kind of Waste	Type of Treatment	Receiving Stream
Slocum Village	- - -	3,000	P	0.24	D.S.	Complete	Slocum Cr.
Smithfield	5,574	4,800	M	0.50	D.S. & I.W.	None	Neuse River
Snow Hill	946	840	M	0.075	D.S.	None	Contentnea Cr.
Stantonsburg	627	620	M	0.037	D.S.	Primary	Contentnea Cr.
State Hospital at Butner	- - -	3,800	I	1.23	D.S. & I.W.	Secondary	Knapp of Reeds Cr.
State Hospital at Goldsboro	- - -	3,500	I	0.50	D.S. & I.W.	None	Neuse River
Wake Forest	3,704	2,500	M	0.25	D.S.	None	Richland & Spring Creeks.
Walstonburg	177	150	M	0.027	D.S.	Secondary	Little Contentnea Cr.
Wendell	1,253	1,700	M	0.24	D.S. & I.W.	Primary	Buffalo Cr.
Wilson	23,010	21,800	M	1.98	D.S. & I.W.	Secondary	Toisnot Swamp & Contentnea Creek
Winterville	870	620	M	0.050	D.S.	Primary	Creek to Swift Creek
Youngsville	619	450	M	0.023	D.S.	Primary	Branch to Richland Cr.
Zebulon	1,378	2,000	M	0.18	D.S.	None	Moccasin Creek
Totals	255,892	229,995		23.509			

I - Institutional
P - Privately Owned
D.S. - Domestic Waste
I.W. - Industrial Waste
RDAA - Raleigh-Durham Airport Authority

* Contract pending for complete treatment facilities

TABLE II

POINTS OF SIGNIFICANT POLLUTION - INDUSTRIAL

INDUSTRY	OWNER-SHIP	KIND OF WASTE	Est. Gals M. G. D.	TREATMENT	RECEIVING STREAM
American Woolen Co.-Raleigh	P	I.W.	.545	None	Ditch to Walnut Creek
Appels Livestock Market - Durham	P	I.W.	.002	Secondary	Discharged to land
Austin Farms Poultry Co. -Wendell	P	I.W.	.003	Grease Removal	----------
Bellvue Mfg. Co.-Hillsboro	P	I.W.	.075	None	Eno River
Carolina Packers-Inc.-Smithfield	P	I.W.	.035	-------	----------
Cary Barrel and Drum Co. - Cary	P	I.W. & D.S.	.011	None	Roadside ditch to Tributary of Walnut Creek
Cone Mills Corp.-Hillsboro	P	I.W.	.022	None	Eno River
C. P. & L. Steam Plant-Goldsboro	P	I.W. & D. S.	108.00	Secondary	Neuse River
Dupont-Kinston	P	D.S. & I. W.	.096	Secondary	Ditch to Neuse River
Eno Steam Station -Durham	P	I.W. & D. S.	96.50	None	Stoney Creek to Eno River
FCX Livestock Market-Hillsboro	P	I. W.	.007	Secondary	Unnamed Creek
General Laundry & Cleaners-Wake Forest	P	I. W.	.020	None	Spring Branch
Hardees Hatchery-Durham	P	I. W.	.002	Secondary	Discharged to ditch
Jones Sausage Co.-Garner	P	I. W.	.003	Grease Removal	Unnamed Creek
Newbern Provisions Co. - Newbern	P	I. W.	.014	-------	Neuse River
Piedmont Packing Co.-Hillsboro	P	I. W.	.008	Secondary	South Fork Little River
Royal Cotton Mills - Wake Forest	P	I. W.	.004	None	Tributary of Richland Creek
Virginia Carolina Chem. Co. Durham	P	I. W.	.002	None	Tributary of Third Fork Creek
Wake Fin. Co. - Wake Forest	P	I. W. & D. S.	2.20	Secondary	Neuse River
Total			206.549		

Organization of Soil Conservation Districts - - Unfortunately, because of the geographical manner in which the Soil Conservation Districts were organized in North Carolina and Virginia, there is no single district which lies wholly within the Neuse River Basin. Parts of the Dan River District, with headquarters at Greensboro, the Tar River District and Neuse River District, with headquarters at Raleigh, the Coastal Plain District and Pamlico District, with headquarters at Greenville, and the Southeastern District and Lower Neuse District, with headquarters at Goldsboro, lie within the Neuse River Basin.

The data, contained in the tables of "Soil Conservation Practices Accomplished" and "Soil Conservation Practices Contemplated" on page 79, were furnished by the State Conservationist, Soil Conservation Service, U. S. Department of Agriculture, Raleigh, North Carolina, and are approximated, because his records are maintained on a District basis and on a County basis. Attempt was made by his office, in each of the counties lying wholly or partly within the Neuse River Basin, to determine a percentage of the total land of each such county that is included in the basin. The percentages so determined were applied to the records of accomplished and contemplated soil conservation practices to arrive at estimated figures for each county. While the State Conservationist realizes that these figures are not exact, he feels that they represent a very close approximation and may be used for all practicable purposes.

The tables indicate some of the major Soil Conservation practices which have been applied and are now on the land in the counties, as well as the estimated amount of work remaining to be done for those practices. The last line on the table of "Soil Conservation Practices Accomplished" and the table of "Soil Conservation Practices Contemplated" indicates, respectively, the present District Cooperators and the farms which have not signed conservation agreements with the District. The large number of "Remaining District Cooperators" on the table of "Soil Conservation Practices Contemplated" does not indicate an unwillingness on the part of those farmers to carry out conservation plans. It simply indicates that the few Soil Conservation Service technicians available to the State Conservationist have been unable to work with those farmers.

SOIL CONSERVATION PRACTICES ACCOMPLISHED

		Beaufort	Carteret	Caswell	Craven	Durham	Franklin	Granville	Greene	Johnston	Jones	Lenoir	Nash	Onslow	Orange	Pamlico	Person	Pitt	Wake	Wayne	Wilson	Total
4 Closed drains	Lin.ft.	1641	17251	--	45442	700	--	--	451544	424323	156017	530157	17098	8233	--	9036	171	670987	11948	110496	78439	2533483
5 Conservation crop rotation	Ac.	29	1792	394	26168	17620	3964	11220	12782	29037	10807	18218	7860	645	13599	5427	20188	9094	41343	22614	21294	274095
6 Contour farming	Ac.	30	106	262	198	6079	2561	5359	3207	5559	3227	2858	3486	79	10832	4	21343	311	15008	3484	2089	86082
8 Contour stripping	Ac.	--	2	7	13	526	391	124	--	798	2922	201	94	1	838	--	1642	--	234	130	120	8043
9 Cover Cropping	Ac.	101	1233	334	--	2084	3619	5946	11013	9039	14206	9653	3039	301	7334	2252	16620	2844	11941	21012	13278	135849
10 Critical area planting	Ac.	--	25	5	248	70	300	--	--	28	284	319	8	24	40	30	502	38	176	350	--	2447
11 Crop residue utilization	Ac.	10	3316	73	19388	4410	1561	1591	20000	3410	21901	19670	5654	228	2539	5679	8539	17593	4554	11027	11670	162813
16 Drainage	Ac.	913	3389	3	6862	750	--	104	9222	7148	4534	6497	367	402	170	5221	370	10200	842	1970	4356	63320
25 Group enterprise	Mi.	5	16	--	51	--	--	--	42.2	--	16	28	--	.4	--	18	--	106	--	9	--	291.6
Group enterprise	Cu.yd.	59061	97931	--	424326	--	--	--	317277	--	163160	217541	--	2250	--	129730	--	1137431	--	28728	--	2577435
28 Improvement cutting	Ac.	--	3660	25	9861	1077	350	1450	--	500	5294	11444	3016	322	841	855	3312	5870	4274	24086	563	76800
32 Open drains	Mi.	21	37	--	103	3	2	1	110	38	124	1042	4	4	--	191	5.4	45	14	34	37	1815.4
Open drains	Cu.yd.	74870	178025	300	527505	2450	--	2800	1114000	8276	619207	532705	3396	18926	120	940777	--	403200	168000	152260	19711	4766528
33 Pasture planting	Ac.	97	1204	86	2515	4564	431	1358	947	2847	2289	2688	430	126	3310	978	4436	1793	4807	980	1989	37875
35 Pond construction	No.	.5	3	2	26	396	28	124	72	337	16	42	31	1	120	1	190	64	698	53	88	2292.5
42 Sprinkler irrigation system	No.	--	1.5	--	3.6	17	2	3	15	3.8	1.6	4.7	5	.1	3	1	19	17	56	1.8	15	170.1
Sprinkler irrigation system	Ac.	--	111	1	45	105	12	70	500	--	22	103	63	2	56	48	--	824	840	118	135	3055
47 Terracing	Mi.	--	--	20	7	806	153	391	76.2	854.9	11	34	194	2	276	--	719	17	1273	100	113	5047.1
48 Tree planting	Ac.	100	6	9	36	454	69	147	85	208	68	61	39	2	283	6	262	15	361	170	224	2605
49 Waterway development	Ac.	--	2	16	10	418	128	173	147	427	11	86	131	4	275	2	623	6	658	61	16	3194
50 Wildlife area improvement	Ac.	--	6	2	74	--	--	--	42	--	98	60	--	.4	--	2	49	7	--	42	--	382.4
Now Dietriot Cooperators	No.	15	97	9	634	707	130	433	674	1083	295	561	208	25	508	182	517	369	1269	510	740	8966

SOIL CONSERVATION PRACTICES CONTEMPLATED

4 Closed drains	Lin.ft.	3359	432749	--	764558	70000	5000	7385	4387656	7650677	7242999	14769498	186526	528717	--	788963	10197	2549013	196052	15069053	8922478	63584880
5 Conservation crop rotation	Ac.	251	7014	348	34267	15616	8728	21638	62292	108812	58866	91818	9742	4647	13150	15497	14265	38145	90420	141904	23364	760814
6 Contour farming	Ac.	170	931	450	16566	30580	3588	25347	14909	137506	11042	25868	13956	1476	15108	2196	13603	1758	123992	46187	46281	531514
8 Contour stripping	Ac.	--	210	268	3100	8433	3027	15136	--	71367	11347	3503	6203	49	12443	--	5093	--	63900	1388	18156	223623
9 Cover cropping	Ac.	469	7513	408	36969	33733	1192	24506	64063	184544	55136	100383	18799	4991	20839	18672	17833	15016	132207	143506	71806	953685
10 Critical area planting	Ac.	--	224	70	4438	700	1700	350	--	9500	3556	3765	300	169	840	374	147	136	12000	5465	720	44454
11 Crop residue utilization	Ac.	290	5490	173	40148	13783	1750	21840	30000	196253	45373	90367	18817	5064	16969	4395	2252	26157	74481	153491	34776	781869
16 Drainage	Ac.	1195	7333	17	50051	5708	556	2888	24778	60989	43003	63170	1760	2478	123	15783	1322	27355	10173	83580	19403	421665
25 Group enterprise	Mi.	5	34	--	315	--	--	--	18.2	--	40	243	--	3	--	65	--	105	--	82.8	--	911
Group enterprise	Cu.yd.	54000	171250	--	2452500	--	--	--	1820000	--	200000	1703738	--	15000	--	39860	--	1050000	--	431272	--	7937620
28 Improvement cutting	Ac.	20	47884	565	254569	25654	5460	41913	10000	123646	87613	65074	12612	9870	22917	56541	10234	35489	81580	79456	32758	1003855
32 Open drains	Mi.	22	68	.3	787	55	13	50	182	646.7	704	276.7	53	52	36.2	427	17.9	362	88	598	274	4712.8
Open drains	Cu.yd.	78400	340725	1700	3927495	21000	10	199150	1892800	95000	3516793	1367295	300000	247824	102388	1947223	--	484750	400000	2745740	75000	17743293
33 Pasture planting	Ac.	283	6482	203	19572	7825	719	5529	2368	33517	12870	10261	2009	516	46441	2713	7425	10496	20412	19930	3787	213358
35 Pond construction	No.	1.5	2	5	.9	752	19	114	200	613	31	82	65	2	360	1.6	484	3.5	681	163	750	4330.5
42 Sprinkler irrigation system	No.	5	6	6	44	62	46	100	100	295	158	1062	58	19	61	6	411	67	585	460	125	3676
Sprinkler irrigation system	Ac.	--	2774	73	405	630	600	1925	2500	3420	1578	10566	750	193	1224	56	--	1293	7680	4600	37500	77767
47 Terracing	Mi.	--	10	37	228	1806	1010	1398	327.8	7448	13	367	638	13	1620	83.7	1711	149	7851	1164.5	1977	27852
48 Tree planting	Ac.	2	25	88	280	851	118	1460	715	2787	32	92	212	83	2022	2	782	60	3438	842	6000	19891
49 Waterway development	Ac.	--	8	31	346	273	36	410	200	721	245	414	160	14	118	11	1047	19	1745	353	763	6914
50 Wildlife area improvement	Ac.	--	32	9	427	--	--	--	175	--	605	246	--	12	--	15	1047	168	--	122	--	2858
Remaining Distriot Cooperators	No.	50	81	21	1477	472	273	713	2177	6268	988	3031	656	83	264	214	714	1643	3546	4012	2337	29020

Neuse River Watershed Authority--Chapter 1115, as amended by Chapter 1319, 1953 Session Laws of North Carolina created the Neuse River Watershed Authority, consisting of two members appointed by the Board of County Commissioners of each county within the drainage area of the Neuse River, namely, Durham, Wake, Johnston, Wayne, Lenoir, Greene, Jones, and Craven Counties. The law directed that, within 60 days after appointment, the members hold an organization meeting in one of the counties involved and select thereat a chairman, vice-chairman, and secretary-treasurer, who would thereupon become members of the Authority. Provision was made that two non-voting advisory members may be appointed by the county commissioners of each of the above counties, and the mayors of the towns within such county, by joint action. Each such county was directed to pay into the office of the secretary-treasurer of the Authority a sum not to exceed $100.00 on July 1, 1953, or upon completion of the organization of the Authority, for organizational expenses incurred during the first year, and thereafter to pay a like sum on the first day of July of each and every year, provided that such need arises in the discretion of the board of the Authority.

Purpose of the Authority--Such purpose is to promote the mutual interests of the several counties, towns, cities, and communities in the Neuse River Watershed area:

(a) In preventing floods;
(b) In regulating stream channels by changing, widening, and deepening the same;
(c) In reclaiming or filling in wet and overflowed lands;
(d) In providing for irrigation wherever it may be needed;
(e) In regulating the flow of streams and conserving the waters thereof;
(f) In diverting or in part eliminating water courses;
(g) In providing a water supply for domestic, industrial, and public use;
(h) In providing for the collecting and disposing of sewage and other waste produce; and
(i) In arresting erosion not inconsistent with Chapter 139 of the General Statutes relating to soil conservation districts.

Powers of the Authority--Such powers are:

(a) By gift, trade or purchase, to acquire equipment, materials, supplies, engineering data, and any other personal property;
(b) To accept, from any person, corporation, town, city, county, State, or the United States, title to, and all rights and interest in, lands;
(c) To enter into agreement with the State or any agency of the State, or with the United States Government or any appropriate agency of the United States Government;
(d) To work out and enter into agreements with the governing bodies of the towns and the several counties within the Neuse River Watershed area for payment to the Authority of a sum reasonably commensurate with any projects intended to conserve and develop the water resources of the Neuse River Watershed;
(e) To provide necessary personnel to maintain proper records

and to secure necessary legal advice in drawing contracts and other papers for the Authority; and

(f) To rent, lease, authorize the sale of, and sell timber, and otherwise handle and dispose of any and all real or personal property that may come within its possession, limited to the promotion of this project as a water resources area.

Annual Report--The law directed that the Authority make an annual report to the commissioners of the several counties and to the governing bodies of the cities and towns cooperating with the Authority.

Meetings of the Authority--The first meeting of the Authority was held in Raleigh on February 13, 1954. The Director of Conservation and Development brought greetings from the Governor of North Carolina and pledged the full support and facilities of the Department of Conservation and Development toward developing better flood control, irrigation, erosion prevention, reforestation, and abatement of stream pollution. Representative Graham A. Barden, Third Congressional District, pledged all possible cooperation with the Authority, including influence in obtaining assistance of the Corps of Engineers, U. S. Army. State Senator Adam Whitley, Johnston County, reviewed the State law which created the Authority. The State Forester indicated that the Division of State Forests, Department of Conservation and Development, was vitally interested in the Neuse River Watershed Area, particularly in connection with State forest nurseries located in Wayne and Johnston Counties. The State Soil Conservationist pledged the help of the U. S. Soil Conservation Service in any possible way. A representative of the Wildlife Resources Commission stated that any program of soil and water conservation would increase and conserve wildlife, and that the Commission was vitally interested in the work of the Authority. The District Engineer, U. S. Geological Survey, advised that topographic surveying and collection of water resources information could be accomplished under a cooperative agreement whereby the Federal Government would match, on a dollar-for-dollar basis, funds provided by local interests. The Director, North Carolina Extension Service, stated that all educational agencies would be glad to assist the Authority's program. The Chairman of the Authority presented a financial report and proposed that a survey of the resources of the Neuse River Basin be made. He stated that the survey would be expensive and that the Authority should give consideration to the method of accomplishment of the survey and the time of its initiation. Four committees, an Education Committee, an Engineering Committee to investigate the cost, and method of accomplishment, of the survey, a Financial Committee, and a Coordinating Committee, were proposed. The Chairman appointed an Education Committee. State Senator J. V. Whitfield expressed the desire of the Governor that the Authority become a model for North Carolina river basin organizations, set forth the program of the State Stream Sanitation Committee pertaining to the Neuse River Basin, and indicated his opinion that it would become necessary for the Authority to obtain funds locally, to be added to Federal and State Funds, in order to accomplish the purposes of the Authority.

The second meeting of the Authority was held in Smithfield on July 15, 1954. The Chief Engineer, Division of Water Resources, Inlets and Coastal Waterways, Department of Conservation and Development, expressed belief that the Authority should initiate as soon as practicable accomplishment of its purpose as set forth in the State law effecting its creation, stated opinion that undertaking of a survey of the basin is the first step toward such accomplishment, and indicated three methods of conducting a

survey. The Chairman stated that he had received proposals from an engineering firm covering a preliminary survey at a cost of approximately $3,000 and a complete survey at a cost of approximately $35,000. Various members of the Board of Directors presented opinions regarding methods of obtaining funds for a survey, including contributions from the boards of county commissioners, soliciting financial subscriptions, developing a membership payment plan involving dues from $5.00 per annum for individuals to $150.00 per annum for large industries, State funds, and assessment of two cents on each $100. of property valuation in each county. The Chairman appointed a Survey Committee to determine and recommend to the Authority a method or methods to accomplish the proposed survey.

Future Activities of the Authority--It is believed that "Water Resources of the Neuse River Basin" will substantially accomplish the purposes of a preliminary survey of the basin and will enable the Authority to take effective action toward accomplishment of its purpose. The Authority may find useful information under "Committee No. X: Organization of Watershed Associations", pages 113-117, "Water Resources of North Carolina".

Operations under Federal Laws Pertaining to Watershed Protection--The 83rd Congress appropriated $10,500,000 for the Federal share in work on the 60 pilot watershed works underway, in October 1954, in 33 states. There are no Pilot Watershed Projects in operation within the Neuse River Basin, nor are there any projects under construction as provided for in Public Law 566, 83rd Congress (see pages 103 and 104, "Water Resources of North Carolina). As of March 2, 1955, one application for Federal assistance, under the provisions of Public Law 566, pertaining to lands in the vicinity of Bear Creek, draining parts of Wayne, Greene, and Lenoir Counties, had been received by the State Soil Conservation Committee (see page 119, "Water Resources of North Carolina"), the agency designated by the Governor of North Carolina to approve applications from local authorities pursuant to Public Law 566, 83rd Congress. Also as of March 2, 1955, the State Soil Conservation Committee anticipated that applications for Federal assistance in connection with Neuse River Basin projects, other than the Bear Creek Project, would be received.

Accomplishment of Navigation Projects - - Information regarding the responsibility of the Corps of Engineers, Department of the Army, for navigation improvements and procedures pertaining to the investigation, planning, and construction of navigation projects may be found on pages 122 and 123, "Water Resources of North Carolina", a publication distribued by the North Carolina Department of Conservation and Development in January, 1955.

Navigation Projects in the Neuse River Basin - - Information regarding navigation projects in the Neuse River Basin is set forth below in the following order: completed projects, projects under way, and preliminary examinations and surveys under way.

COMPLETED PROJECTS

Bay River - - This project provides for a channel, 10 feet deep and 150 feet wide, in Bay River from deep water in Neuse River to a point 3,500 feet below Stonewall; thence 10 feet deep and 100 feet wide to Bayboro; thence 10 feet deep and 50 feet wide up the northwest prong to Mill Dam, including a turning basin 100 feet by 150 feet; also for a channel, 10 feet deep and 100 feet wide, from deep water in Bay River to Vandemere, ending in an anchorage basin of the same depth and 150 feet wide on the north side of the town. The total length of these sections is about 6.75 miles. The project was completed in 1939 at a cost of about $44,400.

The average annual commerce for the period 1947 - 1951 was 4,400 tons, principally fish, shellfish, petroleum products, poles and rafted logs. Commerce in 1951 totaled about 3,700 tons.

Swift Creek - - This project provides for clearing the channel, from the mouth at the Neuse River to Vanceboro, a distance of 12 miles, of snags and overhanging trees. The work was completed in 1910 at a cost of about $1,600. Commerce during 1947 amounted to 91 tons. None has been reported since that date.

Contentnea Creek - - This project provides for maintenance of the stream between its junction with the Neuse River and Stantonsburg, a distance of 68 miles, by removing obstructions from the natural channel so as to obtain a depth of not less than 3 feet during 9 months of the year. Snow Hill, 32 miles above the junction of Contentnea Creek with Neuse River, is practically the head of navigation. The work was completed in 1896 at a cost of $64,400. No commerce on Contentnea Creek has been reported since 1935.

PROJECTS UNDER WAY

Neuse River - - This project provides for a channel 12 feet deep and 300 feet wide, from a point about 10 miles below New Bern, to and in front of New Bern, thence 4 feet deep to Kinston, and 3 feet deep to Smithfield during 9 months of the year. Except for the 200-foot width provided at New Bern, the project was completed to the practicable limit in 1929, at a cost of about $403,100.

Average annual water-borne commerce during the period 1947-1951 has been about 19,900 tons, consisting of petroleum products, lumber, fertilizer and fertilizer materials, rafted logs, sea food, and small amounts of other commodities. Commerce in 1951 was about 20,500 tons.

Trent River - - This project provides for a channel 12 feet deep and 300 feet wide in front of New Bern; a channel 6 feet deep over Foys Flats; a channel 50 feet wide and 4 feet deep to Trenton; and a boat basin at New Bern 600 feet long and 250 feet wide, and a repair basin 300 feet long and 220 feet wide at the adjacent boat works, with an access channel 90 feet wide to each basin, all to a depth of 8 feet. The length of section included in the project is 38 miles.

That part of the project providing for a depth of 12 feet and width of 300 feet in front of New Bern, a channel 6 feet deep over Foys Flats, and a channel 50 feet wide and 4 feet deep to Trenton, was completed in 1929 at a cost of about $115,200. No work has been done on the boat and repair basins and access channels at New Bern. It was estimated, as of January 1, 1953, that this work would cost $24,600. The Chief of Engineers, on September 25, 1941, recommended provision of the boat and repair basins, with access channels thereto, provided that the City of New Bern or other responsible local interests furnish, free of cost to the United States, the necessary rights-of-way and spoil disposal areas for new work and subsequent maintenance when and as required; hold and save the United States free from all claims for damages attributable to the improvement; agree to provide suitable bulkheads, boat slips, walkways, road access, and facilities for servicing boats, open to all on equal terms; and contribute one-third of the amount required for the dredging, but not to exceed $5,500.

The average annual commerce for the period 1947-1951 amounted to 10,100 tons, principally petroleum products, logs, and fertilizers and fertilizer materials.

PRELIMINARY EXAMINATIONS UNDER WAY

Trent River - - An investigation was made by the District Engineer, Wilmington District, to determine the feasibility of an alternative location of the authorized boat and repair basins and approach channels in Trent River. The report of the District Engineer, Wilmington District, concurred in by the Division Engineer, South Atlantic Division, recommended no modification of the authorized project.

CHAPTER XIII - - FLOOD CONTROL

Causes of Floods in the Neuse River Basin - - Floods in general are caused by an excessive rate of precipitation. A number of other factors influence their intensity. These factors include the rate of run-off, the shape of the drainage basin, the character of the stream, and the natural storage available in the valley. Other causes, which may be classed as artificial, are the failure of dams, denudation of the watershed, and encroachments upon the channel of the stream.

A fan-shaped basin causes excessive run-off to reach the main stream quickly while a long, narrow basin will allow the water, which first arrives in the lower reaches, to be discharged before the flood from above arrives, thus avoiding stream congestion. In general, the Neuse River can be considered as belonging to the latter class.

The Neuse River and its principal tributaries are all of a very meandering type, which causes their flood waters to be discharged very slowly. The numerous turns and bends also have a tendency to increase their roughness coefficients and thus decrease their carrying capacities. These adverse effects are partially compensated for by the additional valley storage that this type of stream provides.

A stream with a wide flood plain will, in time of overflow, store large quantities of water in its valley in producing the head necessary to raise the stage below. This storage of water tends to reduce materially the peak discharge of the flood as the wave moves down the stream. The Neuse River and its tributaries have comparatively wide flood plains, and, therefore, considerable reductions in the peak discharges of floods are occasioned through valley storage in the reaches of these streams.

Encroachments upon the channel of a stream, either artificial or those brought about by nature, adversely effect its flood capacity both by decreasing the gradient and area and increasing the roughness coefficient. The upper portions of the Neuse River and its tributaries are comparatively free of such obstructions. However, in the heavily forested coastal region, where the streams are generally narrow and sluggish, trees fall into and sometimes even across them, causing obstructions. This condition particularly exists in the lower reaches of Contentnea Creek, Trent River, and numerous other smaller tributaries in this region. Some of the highway crossings do not have openings sufficiently large to pass freely the flood waters.

Great Floods - - Large floods occurred on the Neuse River in 1887, 1901, 1908, 1919, 1924, 1928, and 1929. The flood of August 1908 was larger than any other freshet on record and caused great damage because of the season of the year in which it occurred. Heavy losses were also occasioned by the July 1919 flood, which was only slightly lower than the August 1908 flood in the lower reaches of the stream. The flood of October 1929 was the highest on record except the August 1908 flood in the upper portion of the river. As the rainfall causing the October 1929 flood was concentrated in the upper portion, flood heights were considerably lower below. It is understood that great floods occurred in 1865, 1877, and in the early 1880's. Nothing is known, however, of their heights as compared with the floods of 1908, 1919, and 1929.

Frequency and intensity of floods - - From a study of the monthly frequency and intensity of floods on the Neuse River at Smithfield, it appears that floods are most likely to occur in February or March but have occurred during every month of the year. They are least frequent in November. It also appears that the higher stages are most likely in the summer and early fall. The greatest number of floods per year occurred in 1929, and they were less frequent in 1916, 1923, and 1926, than in any other years. Flood stage (gage height, 14 feet at Smithfield) was exceeded at least once during every year during the period 1911-1926, inclusive, and there were an average of four freshets annually. Gage heights of 18 feet (4 feet above flood stage) or more occurred as follows:

Date		Gauge height
------,	1887	26.1 (est.)
May --,	1901	25.0 (est.)
Aug.--,	1908	27.1 (est.)
Mar. 17,	1912	18.2
Sept. 5,	1913	19.0
Mar. 7,	1917	18.3
July 24,	1919	26.4
Feb. 5,	1920	18.1
July 22,	1920	19.3
Feb. 18,	1922	19.3
Mar. 6,	1922	19.6
Mar. 19,	1923	18.4
Oct. 1,	1924	24.0
Jan. 14,	1925	18.1
Jan. 22,	1925	18.1
Dec. 6,	1927	18.0
May 3,	1928	18.0
Sept. 7,	1928	21.4
Sept. 21,	1928	22.8
Mar. 7,	1929	21.5
Oct. 3,	1929	26.5

Estimate of maximum flood - - The maximum flood of record at Smithfield (that of August 1908) obtained a maximum discharge rate of 24 cubic feet per second per square mile. Such a flood flow from the Neuse River above Smithfield is regarded as extremely improbable because of the shape of the watershed and its run-off characteristics. It is believed that a flood flow 100 per cent greater than the maximum obtained during the period of record at Smithfield may sometime be expected. Such a flood would obtain a stage of about 35 feet at that point and would cause heavy losses.

Physical features of the stream and their effect on flood damage - - The Neuse River through its upper reaches is confined, except in a few places, within a narrow valley and has a comparatively steep gradient. The banks of the river through this section are usually steep, and there is little bottom land. Consequently, the flood losses here are confined to damage to crops on the few narrow strips of level land occasionally found in the bottoms. Exceptions to this condition are found at the confluence of the Eno and Flat Rivers, about eight miles northeast of Durham, and at the junction of Crabtree Creek and Neuse River, about five miles east of Raleigh. Large areas are subject to flood damage at these two locations. Beginning at a short distance

above Smithfield and continuing to the mouth of the Neuse River below New Bern, the gradient of the river is comparatively flat, and its banks are low. Through this reach, it follows a tortuous course, traversing a valley with a wide flood plain. As the flood waters pour into this section from the narrow valley above and encounter the flatter gradient of the lower river, they can not be discharged as quickly as they are received, thus causing prolonged high stages in the lower valley. A considerable portion of the area thus flooded is under or subject to cultivation, and a great amount of damage is done, particularly if the overflow comes during the season of the year devoted to growing crops. Highways and railways are also damaged, and losses are suffered through the slowing down of business and the interruption to transportation facilities. The same conditions are found in the lower reaches of Little River, Contentnea Creek, Trent River, and other lower tributaries of Neuse River.

Description of flood damages along Neuse River - - Below Smithfield and extending to the Pitchkettle section near the mouth of Contentnea Creek, large areas of fertile bottom lands, which are intensively cultivated, are affected by floods, and much crop damage results therefrom. From the Pitchkettle section to the mouth of Neuse River, the banks are swampy, and little land is subject to cultivation; hence, flood losses are unimportant.

Near Kinston and in the vicinity of Smithfield, as well as at several other points along Neuse River, a number of homes and business establishments are subject to submergence. However, as the waters rise slowly, the occupants have ample time in which to remove their belongings, and the resulting damage is much less than might be expected under the circumstances. Several highways are subject to overflow at their various crossings. Most of these highways are of excellent construction, and little permanent damage results from their inundation, although considerable indirect loss is sustained by the public through hampered communication facilities. Many minor highways and bridges are subject to damage, and, during severe floods, a large number of wooden structures and earth embankments are destroyed. The Atlantic Coast Line, Seaboard Air Line, Southern, Norfolk Southern, and other railroads are affected during extreme freshets. The total area subject to overflow between Smithfield and New Bern, is about 114,000 acres.

Description of flood damages along Little River - - Except for minor damage to crops occasioned by the overflow of the few tillable bottoms located in the upper portion of Little River and that caused through the flooding of relatively unimportant highways, flood losses along this stream are confined to the reach below Bakers Mill, about ten miles east of Smithfield. Beginning at Bakers Mill, the area subject to damage begins to increase rapidly until it reaches a maximum width of about two miles at the mouth of the stream, along which only a few buildings are subject to overflow. Several secondary highways are subject to damage, and losses of this character are of a minor nature. The Atlantic Coast Line and Southern railroads are also affected. Severe floods cause the latter line to be overflowed for a distance of approximately two miles, and heavy indirect damages result from such overflow. The total area, subject to submergence in the reach of Little River from Bakers Mill to its junction with Neuse River, is about 6,200 acres.

Description of flood damages along Contentnea Creek - - In the upper reaches of Contentnea Creek, the flood damages are of the same general character as those sustained in the similar portion of the Little

River Valley. Beginning at Wiggins Mill, near Wilson, and extending to below the mouth of Nahunta Swamp, there are large areas of fertile farm land which are inundated during severe freshets, resulting in large losses to the landowners. The greatest damage of this type is in the vicinity of Stantonsburg. The losses caused by floods from the mouth of Nahunta Swamp to the junction of Contentnea Creek with Neuse River, about four miles below Grifton, are much less severe, as the flood plain becomes narrower and the land less productive.

Numerous secondary highways and bridges are affected during the reaches of Contentnea Creek described above. During severe floods, considerable damage to wooden structures and earth embankments is caused. State Highways Nos. 11 and 123 are overflowed. Because of their permanent nature, however, little damage is sustained other than the indirect losses resulting from the blocking and detouring of traffic. A few dwellings in the towns of Stantonsburg, Snow Hill, Hookerton, and Grifton are occasionally inundated. As the flood waters rise slowly, little permanent damage results from such inundation. Moving goods and loss of business causes the owners some monetary damage and considerable inconvenience. The area subject to overflow between Wiggins Mill and the junction of Contentnea Creek with Neuse River comprises about 26,000 acres of land.

Description of flood damages along Trent River - - The flood damage sustained in the upper reaches of this stream is inconsiderable. The principal losses are occasioned through the overflow of cultivated lands between Trenton and Pollocksville. A few buildings in these towns are slightly affected, resulting in minor damage and much inconvenience to the owners. Numerous secondary roads and bridges are overflowed by the larger freshets, causing considerable loss. State Highway No. 12 and the Atlantic Coast Line Railroad are slightly affected at rare intervals.

Losses caused by great floods - - Several large floods are known to have occurred on the Neuse River and its tributaries between the Civil War and the flood of 1887. No record of their size, or the extent of the damage occasioned by them, exists. The table below shows the estimated damages occasioned by floods in the lower reaches of the Neuse River and its principal tributaries. The losses along the main stream and Little River have been combined because much of the damage along Little River has been caused by backwater from the Neuse River.

Date of flood	Gage height at Smithfield	Area below Smithfield and Bakers Mill along Neuse and Little Rivers	Area below Wiggins Mill along Contentnea Creek	Area below Free Bridge along Trent River
July 1919	26.4	$2,300,000	$500,000	$75,000
Oct. 1924	24.0	1,300,000	400,000	------
Sept. 1928	22.8	1,000,000	500,000	50,000
Oct. 1929	26.5	700,000	300,000	------

It will be noted that the damage sustained during the 1929 flood is light in comparison with that caused by other floods of similar gage height. This flood was largely confined to the upper reaches of the stream and only reached moderately high stages below Goldsboro.

Floods against which protection should be provided - - The losses due to floods along the Neuse River and its principal tributaries consist principally of damage to crops, railroads, and highways, and in indirect losses occasioned through the flooding of main arteries of communication. No loss of life caused by floods has ever been recorded, and few buildings are affected. The damages are confined principally to the lower reaches of the streams. Consequently, the question of determining the extent to which flood control would be warranted is purely an economic one. After giving due consideration to the nature, frequency, and extent of flood damages in these areas, the conclusion has been reached that complete control of floods larger than the 10-year flood -- i.e., the flood which will probably be exceeded at least once in each 10-year period -- would not be warranted. Works which would provide absolute protection against such a flood would materially lessen the effects of greater floods, and the interest on the sum necessary to provide greater protection would probably more than pay for the damages which would be caused by them. The 10-year flood would reach a stage of approximately 24.8 feet at Smithfield. Damages begin to occur at this point at a stage of 16 feet.

General methods employed in flood prevention - - In general, flood protection or prevention may be secured by the following methods: By protective works such as levees and dikes; by channel improvements, such as deepening, widening, clearing, and straightening the channel of the stream; by diverting a portion of the flood waters of the stream to other drainage basins; by retention or retarding reservoirs, by means of which the flood waters are stored to be discharged later when the flood has subsided; or by a combination of any or all of the methods enumerated above.

Levees and dikes - - Levees and similar works for flood control are intended to keep a certain area from being flooded. In order that this may be accomplished, it is necessary to afford absolute protection against the greatest overflow that can be expected, because works of this type will not stand over-topping without resulting in great damage to them. Because of the character and frequency of the flood losses on the Neuse River area, it would be uneconomical to provide complete protection against all overflows. Therefore, this method of flood prevention is not considered feasible on the Neuse River area.

Channel improvements - - This method of controlling the floods on a stream has been often used, and, if it can be obtained economically, is perhaps one of the most desirable methods to employ. In order to determine the merits of this type of protection as applied to the Neuse River and its tributaries, the effect of this method of relief at Smithfield has been investigated. The results of these investigations disclose that, if the banks of the stream were cleared and its channel straightened where necessary and cleaned out, the height of the 10-year flood at this point would be reduced from 24.8 feet to about 22 feet. The effect of these improvements on greater floods would be materially less. In order that the desired protection might be obtained (i.e., complete control of the 10-year flood), it would be necessary practically to double the effective cross-sectional area of the present channel, in addition to the improvements described above. To improve the stream in this manner throughout most of its length below Smithfield, as would be required in order to obtain the desired protection, would require an enormous expenditure of funds, particularly for new bridge construction. It is not

believed, therefore, that this method of flood control is practicable for use as a comprehensive scheme on the Neuse River. It might, however, prove practicable on some of the smaller tributaries of the river and at certain points where protection seems desirable.

Diversions - - This method of flood prevention is possibly the best that can be employed, if it is adaptable to the topographic conditions found in the area to be protected. However, diversions from the Neuse River Basin are not economically or topographically possible.

Retention or Retarding Basins - - Retention or retarding reservoirs not only serve the purpose of providing protection against damaging floods but also benefit the area by causing a more constant rate of flow in the streams to be used for navigation, municipal and industrial purposes, and improving sanitary conditions. Also, any amount of control deemed economically desirable can be secured by this method of prevention. It appears that such storage basins can be economically constructed on the Neuse River and its tributaries, two on the Neuse River at the Falls of the Neuse and at Wiggins Mills, one on the Little River at Bakers Mill near Princeton, and one on Contentnea Creek near Wilson.

Investigation of the Neuse River and its Tributaries for Navigation, Flood Control, and Other Purposes - - The District Engineer, Wilmington District, Corps of Engineers, U. S. Army, submitted a report, dated October 15, 1930 and published in House Document No. 500, 72nd Congress, 2nd Session, entitled "Improvement and Development of the Neuse River, N. C.", in compliance with the provisions of the river and harbor act of January 21, 1927. In this report, the estimated costs of the storage basins indicated in the preceding paragraph, including dams, reservoirs, damages, and relocations are shown as follows:

Falls	$1,331,817
Wilson Mills	1,460,240
Bakers Mill	872,816
Wiggins Mill	624,756
Total Cost	4,289,629

It was estimated in the report that the total annual value of the benefits of the flood prevention plan for construction of the four storage basins would be $600,000. The report contains the following conclusions.

The floods on the Neuse River and its tributaries cause no loss of life, and, therefore, the benefits of flood prevention are purely economic in character. The flood protection proposed is largely of local character and benefit. The United States has no interest therein from the standpoint of navigation or as an extended problem of flood control involving several States. However, any damaging floods result in a decrease in the revenues received by the Federal Government from the area affected, and a depression of business follows which has an influence beyond the limit of the flooded areas. The total of these two factors as compared with similar damages suffered by the State, counties, municipalities, corporations, and individuals, might be used to determine the proportionate share of the cost of a flood-control program which should be borne by the Federal Government. Such total was considered to be practically impossible of accurate determination. In this instance, it was believed that the Federal Government's share of the cost would be very small.

It appeared, therefore, that the initial and maintenance costs of works constructed on the Neuse River and its tributaries in the interest of flood control might be borne by local interests with the participation of the Federal Government limited to snagging operations as authorized under existing projects, which, even though conducted primarily for navigation, might benefit flood control.

The District Engineer recommended that a report be made to Congress that the control of floods on the Neuse River and its tributaries was believed to be economically justified, that the cost of construction and maintenance of the works to be built for flood control be borne by local interests, and that the participation of the Federal Government in this flood control be limited to snagging operations to the extent authorized by existing projects.

The Chief of Engineers, in his report dated May 31, 1932 and submitted to the Secretary of War for transmission to Congress, concurred in the opinion of the Board of Engineers for Rivers and Harbors that no further improvement of the Neuse River by the Federal Government for navigation in connection with power development, flood control, or irrigation, or any combination thereof, was justified at that time. The Chief of Engineers stated that there appeared to be no warrant for further improvement for navigation, that, while the district engineer's study indicated that construction of flood control reservoirs in the Neuse River Basin was economically justifiable, the cost of such a project was greater than the sum that could be assessed against the lands benefited; that the project was not, therefore, economically advisable in the sense that it would be self-supporting; and that the general benefits from the flood control project were not sufficient to warrant Federal participation in the cost.

Goldsboro Flood Control Project - - A public hearing was held at Goldsboro on November 3, 1937, pursuant to an item in the River and Harbor Act approved August 26, 1937, which authorized a preliminary examination and survey of the Neuse River with a view to improvement for navigation and flood control between the Johnston County line and New Bern. A preliminary report was submitted in compliance with the item referred to above, and, after review of the report by the Board of Engineers for Rivers and Harbors, a survey was authorized.

Local interests stated at the hearing that conditions could be considerably improved by clearing the Neuse River of obstructions, cutting off sharp points, and making cut-offs at certain places, especially at a bend near Goldsboro. Protection of some areas by levee construction was also suggested. While no improvement designed primarily to increase navigation facilities was desired at that time, it was stated that some incidental benefits to navigation would result from the other works proposed. No specific offer of local cooperation was made.

The survey report of the District Engineer, Wilmington District, dated February 27, 1940 and published in House Document No. 327, 77th Congress, 1st Session, contains the following information.

Gage Heights at Smithfield - - Maximum annual gage heights at Smithfield, in addition to those shown above under "Frequency and intensity of floods", were as follows:

Oct. 3, 1929	26.5
Feb. 5, 1930	14.5
Aug. 7, 1931	19.0
Mar. 9, 1932	18.4
Apr. 19, 1933	16.5
Dec. 2, 1934	22.5
Sept. 8, 1935	15.5
Apr. 9, 1936	20.7
Jan. 31, 1937	19.2
July 31, 1938	19.5
Aug. 31, 1939	19.5

Damages - - The principal damages caused by floods on the Neuse River are those to growing crops. The total amount of cultivated land lying within the maximum observed flood plain, and extending from the westerly line of Johnston County to New Bern, is about 20,000 acres. Of this acreage, only a small amount lies above Smithfield. From Smithfield to the Wayne County line there are about 5,200 acres, most of which are in small isolated tracts not inundated by ordinary floods. From the Wayne County line to the crossing of United States Highway No. 117 just south of Goldsboro, there are about 5,200 acres, a large portion of which are in large, contiguous tracts just above Goldsboro and adjacent to the mouth of Little River. From Goldsboro to the Lenoir County line near Seven Springs there are about 6,600 acres, a large portion of which are in adjoining tracts on the southerly side of the river in the vicinity of Arringtons Bridge. From the Lenoir County line to Kinston there are about 1,800 acres, which, with the exception of the area across the river from Kinston, are generally located in a narrow belt adjacent to the flood line. Between Kinston and New Bern there are about 1,200 acres in comparatively small, isolated tracts bordering the flood line.

Another class of damages is that to highways and roads. Above New Bern, to and including the bridge at Smithfield, the river is crossed by five primary United States highways, three primary North Carolina highways, and seven secondary county roads. These crossings generally consist of a bridge structure spanning the ordinary river channel, flanked by roadways on solid-fill embankments extending from the bridge abutments across the natural flood channel to the high grounds. In many cases, these crossings constitute obstructions to the free passage of floods, and the embankments are damaged by flood currents. During major floods, some of the embankments are overflowed, and considerable intangible losses occur due to interruption of traffic. The flooding of secondary roads along the routes of school busses constitutes a hazard in their operation and frequently interferes with school attendance.

Within the limits of towns and cities there has been comparatively small damage to residential and industrial property, practically none at or above Smithfield. There are a few city blocks of low-grade residential property occupied mostly by a shifting population, lying westward from the Union Station at Goldsboro, that are occasionally inundated by flow from Little River. A small portion of the business section at Seven Springs (Mile 75) is affected by major floods. On a low-lying point of land opposite the city of Kinston (Mile 50) is a section known as Happersville, containing a few cheaply constructed and poorly maintained houses, which is inundated at even ordinary flood stages. There is no damage of this character below Kinston.

It is estimated that the total possible crop loss due to the maximum observed flood, if all crops were totally destroyed, would be $814,500, distributed by counties as follows: Craven, $49,800; Pitt, $6,450; Lenoir, $122,625; Wayne, $424,125; and Johnston, $211,500. During the 29-year period for which complete gage records are available, there have been only two floods that exceeded a stage of 24 feet on the gage at Smithfield (10 feet above flood stage), one of 26.4 feet in July 1919 and one of 26.5 feet in October 1929. All crops grown in this section have matured by October; all of the tobacco has been taken from the fields, and most of the corn has been harvested. Even a July flood would not cause a total loss of all crops. It is believed that crop losses would seldom, if ever, exceed 50 per cent of the total crop value. On this basis, the crop loss due to these two floods would be equivalent to an annual loss of about $30,000. It is estimated that floods of lesser proportions than the maximum would increase the total annual crop losses by 50 per cent, making the total estimated annual crop losses $45,000.

From information obtained from the State Highway Commission, the annual damage to roads and bridges due to major floods are estimated at $4,000. There are other losses and damages such as depreciation of property values, loss of business, emergency expenses for salvage and sanitation, interruption to traffic, interference with school attendance, aggravation of malarial conditions, and other similar conditions. Detailed studies of the damage occasioned by the Ohio River flood of 1937 show that losses of this character amounted to about 50 per cent of the actual tangible damage. As the areas here considered are largely agricultural, however, it is believed that the percentage of such losses would be smaller. Using 10 per cent as a basis, the total annual losses of this character are estimated at $4,900. The total annual losses may then be summarized as follows:

Crop damages - - - - - - - - - - - -	$45,000
Roads and bridges- - - - - - - - - -	4,000
Other losses - - - - - - - - - - - -	4,900
Total- - - - - - - - - - - - - -	$53,900

Costs and Effects of Various Methods of Flood Protection - - The survey had for its objects the securing of data from which to estimate the cost and effect of relieving the flood conditions by any combination of the following methods: (a) snagging and channel clearing, (b) creation of a shallow-depth retarding-reservoir at Beaver Dam Swamp (Mile 111), (c) detention reservoirs at and above Smithfield, (d) levees, (e) increase of cross-sectional area available for flood flow at bridge crossings, and (f) construction of a cut-off at Goldsboro.

Snagging and Channel Clearing - - An allotment of $25,000 from the appropriation for maintenance and improvement of existing river and harbor works was made on July 15, 1939 for snagging and clearing the channel under the existing project. Work, planned to cover a 16-mile reach above Goldsboro and a 5-mile reach below Kinston, was started on November 3, 1939. It was believed that this work would afford at least temporary relief in certain localities.

Creation of a Shallow-Depth Retarding-Reservoir at Beaver Dam Swamp - - Consideration was given to a dam with a crest elevation of 80 feet. Crests higher than elevation 80 appeared impracticable due to the increasing amount of cultivated land that would be overflowed. The channel

portion of the dam considered would be permeable below bankfull stage and the remaining portion impermeable. The net storage available for reducing the discharge of any given flood below the dam would be the volume from the water-surface profiles for the flood in its natural condition, and as modified by the dam. The maximum effect of such a dam in reducing discharge occurs when the water surface reaches the crest of the dam and decreases rapidly to an inappreciable amount as the water surface rises above the crest. Using net storage curves, the freshet of December 6, 1934 (maximum gage height at Smithfield -- 22.5 feet) was routed through the reservoir. A freshet of this size may be expected, on the average, about once in 5 years. The net storage available was about 18,000 acre-feet, while the total volume passing the site during the freshet was about 260,000 acre-feet. The proposed dam showed no effect in reducing the peak discharge. Computations also showed that the dam considered with crest at elevation 80 would have an appreciable effect only on the very small floods with an average frequency of about 2 years or less. It was concluded, therefore, that a retarding dam of the maximum practicable height would provide little relief from floods, and no estimate of cost for such a structure was prepared.

Detention Reservoirs at and above Smithfield - - The plans submitted in House Document No. 500, 72nd Congress, 2nd Session, indicated above under "Retention or retarding basins" and "Investigation of the Neuse River and its tributaries for navigation, flood control, and other purposes", were reviewed. It was believed that there had been no change in conditions since that time that would alter the conclusion then reached, namely, that control by this method was not economically advisable.

Levees - - Most of the cultivated land for which protection is desired lies in a narrow belt bordering the flood. The area protected per linear foot of levee is generally so small that the benefits are not commensurate with the cost. The area of cultivated land on the right bank of Neuse River immediately below Arrington Bridge (Mile 92) appeared the most favorable for protection by levees, since the area protected per front foot of levee would be greater than at other localities. A plan was considered for protecting about 1,300 acres in this locality, by a levee, against a flood equal to the maximum of record. The length of the levee would be about 24,000 feet, and its average height about 6 feet. The computations indicated that the annual charges would exceed the average annual benefits by a considerable margin. In view of the small height of this levee, protection against lesser floods by a lower levee would not be justified, and it was concluded that protection of agricultural lands by this method was not warranted.

Increase of Cross-Sectional Area Available for Flood Flow at Bridge Crossings - - In order to compute backwater curves, cross sections of the flood plain were taken at all bridge openings in the section between the Broadhurst Bridge at mile 82.2 and Richardson's Bridge below mile 122, and at 15 other points between these limits. At Toler's, Cox's, and Richardson's Bridges, the channel openings have areas of 4,650, 5,100, and 3,350 square feet, respectively. Toler's Bridge (Mile 106) has, in addition, a flood opening with an area of 332 square feet. At all of these locations, the embankments are considerably lower than the under sides of the bridges, and are overflowed during severe floods. During the flood of August 1939, when the Goldsboro gage registered 19.2 feet, portions of the embankments at Cox's and Richardson's Bridges were overflowed to depths of 5 and 2 feet, respectively, while the low point of

the embankment at Toler's Bridge was 4 feet above this stage. At the Atlantic Coast Line Railroad bridge at mile 94.2, there is a channel opening of 16,900 square feet, with an additional flood opening of 800 square feet located about 1,500 feet north of the bridge. At the bridge on United States Highway No. 117 near mile 95, there is a channel opening of 7,000 square feet, and no flood opening. About 1,000 feet of the embankment on the north side is overflowed at a stage of 25.8 feet. No appreciable obstruction to the passage of flood flow was observed at any of the bridge crossings.

Construction of a Cut-Off at Goldsboro - - The District Engineer, Wilmington District, decided that the excavation of a cut-off channel across the bend located above mile 95 was the only advisable method, among the six methods indicated above, of relieving the flood conditions. He proposed the construction of the cut-off by excavating a pilot cut in the form of a spillway channel, having a bottom width of 20 feet and side slopes of 1 on $1\frac{1}{2}$, leaving the river at mile 102.5 and emptying back into the stream at mile 94.8. The spillway channel would be about 6,400 feet long (including 180 feet of river crossing), while the distance around the bends is about 7.7 miles. The low-water slope in this distance has a fall of about 7.5 feet. He further proposed to excavate the upper end of the cut-off to an initial elevation of about 2 feet below the low-water plane, so that at the lower stages a portion of the flow would continue to pass through the existing channel and furnish sufficient flow to dilute the effluent from the Goldsboro sanitary sewer outlet, located just below the mouth of Little River. A check dam of creosoted timber piles protected by riprap, located near the upper end of the cut-off, was included in the plan in order to insure the maintenance of the low-water flow in this section of the river. At higher stages, the cut-off would divert a portion of the flood discharge on the steeper gradient of about 5 feet per mile.

Benefits of the Cut-Off - - The District Engineer determined the total annual losses that would be prevented by the proposed plan as follows:

Damages to crops - - - - - -	$2,300
Damages to roads - - - - - -	400
Indirect damages - - - - - -	300
Total - - - - - - -	$3,000

He concluded that there would be certain intangible benefits, such as the improvement of sanitary and drainage conditions, alleviation of malarial conditions, savings in crop losses by passing floodwaters more quickly, and the general welfare and social security of a large population; that, while these benefits could not be evaluated, they would be of sufficient importance to be considered; that the proposed cut-off would benefit the largest body of contiguous cultivated lands within the flooded area of the river basin, containing an appreciable percentage of the total; that the benefits of this protection would accrue to a large number of individuals engaged in various industries; that the construction of the cut-off is advisable; and that the benefits would be sufficient to justify the cost of the plan.

Recommended Work - - The District Engineer recommended that a cut-off channel, extending 6,400 feet across the bend in Neuse River located just above mile 95, be provided for the control of floods in the

vicinity of Goldsboro, at an estimated cost of $49,700 with $1,200 annually for maintenance (net Federal annual charges $3,430).

Report to the Congress and Action Thereon - - The Chief of Engineers, U. S. Army, in his memorandum to the Secretary of War, dated May 9, 1941 and submitting for transmission to Congress his report on preliminary examination and survey of Neuse River, N. C., with a view to improvement for navigation and flood control between the Johnston County line and New Bern, authorized by the River and Harbor Act approved August 26, 1937, recommended construction of a flood channel cut-off on Neuse River in the vicinity of Goldsboro, N. C., substantially as outlined, in the report of the district engineer, at an estimated first cost to the United States of $40,000 for construction with $1,000 annually for maintenance; subject to the provisions that responsible local agencies give assurances satisfactory to the Secretary of War that they will provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the project, bear the expense of the necessary highway bridge across the cut-off, and hold and save the United States free from claims for damages resulting from construction of the works. The Congress authorized the project as recommended by the Chief of Engineers and appropriated the necessary funds for the construction thereof. The project was completed in May 1948 at a cost of about $50,500 to the Federal Government and $16,400 to local interests, including the cost of a bridge across the cut-off.

Emergency Flood Control Work - - During the fiscal year 1952, a Federal allotment of $50,000 and a contribution by local interests were received by the District Engineer, Wilmington District, for clearing and snagging Trent River between mile 38 and mile 75.5 above the mouth at New Bern. As of January 1, 1953, the project was about 25 per cent complete. About $19,500 was expended on the upper 9.2 miles of the project. It was expected that the project, when completed during the fiscal year 1953, would substantially lower flood stages and decrease the time of flooding above and along the improved reach, thereby providing flood control and improving drainage on about 5,000 acres of land.

PRELIMINARY EXAMINATIONS AND SURVEYS UNDER WAY

Cove Creek - - As of January 1, 1953, an investigation to determine the advisability of flood control and drainage improvements in the Cove Creek basin was expected to be completed by the District Engineer, Wilmington District, during the fiscal year 1953.

Neuse River Between Smithfield and Wayne County Line - - As of January 1, 1953, an investigation to determine the feasibility of flood-control improvements for farm lands along a 35-mile reach of Neuse River was expected to be completed by the District Engineer, Wilmington District, during the fiscal year 1953.

Neuse River and Tributaries - - As of January 1, 1953, the date of completion of an investigation by the District Engineer, Wilmington District, to determine the feasibility of providing improvements to reduce floods, facilitate drainage, and permit higher utilization of land and water resources in the Neuse River Basin, was indefinite.

CHAPTER XIV - - CONCLUSIONS

Analysis of the preceding thirteen chapters has resulted in formulation of the following conclusions.

DESCRIPTION OF WATERSHED

1. Most of the reservoir and power sites are found in the Piedmont section.

2. The mean annual precipitation ranges from 42 inches at the northwestern end of the basin to 55 inches near the coast at New Bern. This rainfall is generally well distributed throughout the year, and is greatest during the summer and early autumn.

USE OF WATER FOR DOMESTIC AND MUNICIPAL PURPOSES

3. The per capita use of water is increasing rapidly. The average daily per capita use of surface water in six cities in the basin in 1940, 1950, and 1954 was 59.7, 82.2, and 99.4 gallons, respectively. It is estimated that the water used daily for domestic and municipal purposes, which was approximately 42 million gallons in 1954, will amount to approximately 75 million gallons in 1970.

4. The total use of surface water for all purposes, except water, probably is in the order of magnitude of about 200 million gallons per day. Total withdrawals of ground water aggregate about 80 million gallons per day.

USE OF WATER FOR AGRICULTURE

5. Many farmers have found that irrigation of corn is profitable. The water needs of corn are greatest and most critical during the silking and tasseling periods. Results of research show that irrigation increased the quality of tobacco and the profit derived therefrom.

6. In addition to reducing requirements for food concentrates, more and better livestock can be produced if irrigated pasture is provided to supplement natural range.

7. High stream flows in the basin generally occur when there is little need for irrigation water. Storage of water in surface reservoirs during high flows, and diversion thereform when needed for irrigation, are essential for satisfactory crop protection and for the greatest practicable use of water supplies in many areas.

8. Public Law 597, 83rd Congress, makes available to farmers a new type of credit to finance soil conservation measures. This law makes it possible for the Government to insure conservation and water facility loans advanced by private lenders. It should aid in bringing about desirable uses of acres diverted from the production of surplus crops, as well as relieve the impact of drought conditions. It will provide a part of the capital needed for a well planned program for resource conservation. The loan services authorized by it will be made available through the Farmers Home Administration, which has either full-time or part-time offices

located at each county seat in the basin and staffed with County Supervisors experienced in the handling of a wide variety of credit services. Technical assistance from them will be limited to aiding applicants in determining that the engineering is feasible, that the cost estimates and plans are complete and reasonable, that the proposed improvements are economically sound and are in accordance with practices recommended by the Agriculture Extension Service and the Soil Conservation Service, and that the work meets approved standards.

9. The number of farms equipped to irrigate during dry seasons may be expected to increase greatly in coming years. There has been a significant increase in the use of ground water for irrigation. All agricultural uses of ground water aggregate an estimated 3 million gallons per day. No estimate of the total volume of surface water used for agricultural purposes is available.

USE OF WATER FOR INDUSTRIAL PURPOSES

10. Most of the water for industrial use is obtained from streams and is supplied to industries by the cities and towns in which the industries are located. Estimates of the quantities used are not available in most cases.

11. The total volume of stream flow withdrawn for industrial use is probably in the order of magnitude of 150 million gallons per day. Industrial use of ground water is estimated to be about 30 million gallons per day.

USE OF WATER FOR RECREATION

12. Swimming, fishing, and boating facilities are available in two State parks in the Neuse River basin, and a third State park affords swimming facilities. It is estimated that there are about 100 municipal parks in the basin, which provide recreational facilities, including tennis, softball, and swimming.

13. The coastal area adjacent to the Neuse River Basin includes parts of Pamlico Sound, Core Sound, and the Atlantic Intracoastal Waterway. The recreational facilities in this area attract tourists from many states, and the revenue derived from them, in addition to that from commercial fishing, adds greatly to the prosperity of the region.

14. Facilities for recreation in the form of swimming, fishing, and boating are available in a considerable number of the 30 natural, and 21 man-made, lakes in the Neuse River Basin.

USE OF WATER FOR ELECTRIC POWER

15. Except at the Falls of the Neuse in Wake County and at the points where the lower tributaries of the main stream cross the "fall line", no concentrated head is available below sizable drainage areas, and, therefore, few natural power sites exist. These factors have caused the larger power interests to install their plants on other streams where more constant

flow is available, better natural sites exist, and appreciable storage could be more economically obtained.

16. Centralized production of large plants, distribution of electrical energy by transmission lines, and comparatively low rates for this type of power have caused the abandonment of many small isolated water-power developments on the streams in the Neuse River Basin.

17. On account of the small drainage areas of the streams, their variable flow and their lack of concentrated fall, the production of appreciable quantities of continuous power on the Neuse River and its tributaries is impossible without storage.

18. The Corps of Engineers, U. S. Army, studied sites capable of providing storage and head, and prepared a plan embodying the construction of four projects on the Neuse River and one each on Little River and Contentnea Creek. A comparison of the annual benefits with the annual charges showed that the revenue to be anticipated from the proposed power scheme as a whole would not warrant the expenditure that would be required for its installation. It was concluded that some of the individual projects, embodied in the proposed plan, might at some future date become feasible should fuel costs become higher.

SURFACE WATER

19. The basis of stream-flow information is the continuous record of flow at gaging stations on the rivers and smaller streams. At present, 14 gaging stations are operated within the Neuse River Basin, some of which have been maintained since 1925. On many small streams where no continuous records of flow are available, measurements of stream flow have been made during periods of low flows to supply a more complete coverage of the area. Records of daily flows and results of miscellaneous measurements are published in annual Water-Supply Papers of the U. S. Geological Survey.

20. In general, the flows of the streams in the Neuse River Basin are affected little by the artificial control of man. Among the exceptions are Lake Michie on Flat River and a storage reservoir on Contentnea Creek.

21. In water shortages that have occurred in recent years, most problems were the result of inadequate original planning or of increased demands outrunning the expansion of facilities. Problems in water supply generally occur only at times when stream runoff is considerably below normal, and they are often mistakenly referred to as drought shortages when they really should be described as resulting from inadequate planning.

22. In analyzing the adequacy of a specific source for water supply, the requirements will be known for water consumption or for waste disposal. To meet these requirements, the per cent of time the flow is sufficient to meet the needs must be determined. For the per cent of time that the supply is insufficient, information is also required on the frequency with which such conditions recur, how long they persist, and what storage requirement would be necessary to meet the deficiency.

23. The flow-duration curve may be used to estimate the probable occurrence of a specified discharge. The slope of the curve is a good index of the natural storage within a basin, including the ground-water storage; that is, the flatter the general slope of the curve, the lower the flood peaks and the higher the sustained dry-weather flow. Streams having a high dryweather flow are the best for a source of water supply.

24. The curve for magnitude and frequency of low flows indicates the average frequency of occurrence of a specified discharge. Careful analyses of low-flow characteristics may also include curves that indicate the minimum number of consecutive days during which the flow will be less than a specified discharge.

GROUND WATER

25. In the Piedmont section of the basin, the yield of wells is not very great, being rarely as much as 100 gallons per minute and usually less.

26. In the Coastal Plain, wells yielding more than 200 to 300 gallons per minute are common. Ground water is used for domestic supplies by 62 per cent of the basin's population.

27. In the Piedmont section, most domestic supplies are obtained from dug or bored wells which are generally carried down to hard rock. Such wells average about 40 feet in depth and furnish enough water for household use, except in very dry summers. It is generally uneconomical to drill wells to depths greater than 300 feet. In the slates and granites, the best wells may yield as much as 50 gallons per minute. Wells yielding more than 25 gallons per minute are not common. Average yields of wells drilled in the shales are only 15 gallons per minute. As much as 30 gallons per minute may be obtained from the more permeable sandstones or from fractured zones near dikes.

28. In the Fall Zone Province of the Coastal Plain, dug well points are common. The latter type of wells are rarely deeper than 50 feet. Good yields are obtained if sand strata are encountered in drilling. Maximum yields are generally obtained if wells are drilled through the Coastal Plain strata and into the underlying slates. Most of the available water will be obtained within 300 feet of the surface. The best wells have produced as much as 200 gallons per minute. Such large yields generally decline slowly over a number of years. Wells drilled in favorable places may yield 50 to 200 gallons per minute.

29. In the Cretaceous Sand Province of the Coastal Plain, wells range in depth from 100 to more than 600 feet, aggregate yields generally increasing with depth. Yields in excess of 500 gallons per minute have been obtained from wells in this province.

31. In the Composite Limestone-Sand Province of the Coastal Plain, wells range in depth from 100 feet to more than 600 feet. This province is an intermediate zone in which adequate ground water supplies may be obtained from the Tertiary limestone near the surface or from the Cretaceous sands beneath. Yields of wells are comparable to those in the adjoining ground-

water provinces. Generally, a well yielding more than 500 gallons per minute is obtaining water from both aquifers.

32. Many people in the Neuse River Basin, and elsewhere in the State, believe that ground water levels are becoming lower each year. Although rainfall is the source of ground water, water levels are not highest during the summer months when rainfall is greatest. Generally, the water table is at its highest level in the spring. High rates of evaporation and transpiration, high human consumption, and the intensity of summer storms remove much ground-water from storage or prevent effective ground-water recharge so that water levels reach their lowest points at the end of the growing season.

33. Sometimes, drainage works are constructed to lower permanently the water table in swamps and meadow lands so that more valuable crops may be raised. In the Neuse River Basin, such drainage projects have been effective locally. They have not been extensive enough, as yet, to lower water levels over wide areas.

34. Most of the concern about falling water levels naturally arises toward the end of the growing season when water levels are at their lowest in the natural cycle. Few persons realize that the water table is at its usual high level every spring and that the average water level at any season remains relatively constant. Ground water levels are not becoming lower in the Neuse River Basin, or elsewhere in North Carolina.

35. Preliminary studies indicate that the quantity of water now withdrawn from ground water reservoirs in the Neuse River Basin is but a fraction of the total available supply. A great expansion of ground water supply facilities is feasible, at this time, throughout the basin.

36. Wells must be properly spaced to prevent mutual interference. This problem is not too serious in the Piedmont or Fall Zone ground water provinces where the permeability is relatively low and yields are small. In the area underlain by the very permeable Cretaceous sands and Tertiary limestones where large yields are expected, the problem is more acute, especially as it relates to salt water contamination. It is very important that wells be properly spaced, not only to prevent interference with production from other wells, but also to prevent combined production from lowering water levels to such an extent as to allow salt water to rise into the wells, rendering them unfit for use.

37. In that part of the Neuse River Basin where salt-water contamination is possible, most wells have excellent yields, some furnishing as much as one million gallons per day. Under present conditions, heavy pumping may be safely continued or, at some places, increased without danger of contamination. Before installing a large ground-water supply-system, a municipality or an industry should obtain as much information as possible regarding the geology of the aquifer and its known hydrologic properties. It may be necessary to drill several test wells to determine the depth to the salt water body and the possibility of contamination.

ABATEMENT OF STREAM POLLUTION

38. The State Stream Sanitation Committee expects to complete studies in the Neuse River Basin, including investigation of water and

land uses, sources of pollution, and determinations for physical, biochemical, and bacteriological characteristics of water taken from the streams, during the summer of 1955, Upon completion of the studies, a comprehensive report will be prepared. Public hearings and classification of streams are expected to take place by the end of 1956.

SOIL CONSERVATION

39. As of March 1, 1955, 8,966 soil conservation district cooperators had accomplished soil conservation practices in the Neuse River Basin, including closed and open drains, crop rotation, contour farming, cover cropping, group enterprises, pasture planting, pond construction, installation of irrigation systems, terracing, tree planting, waterway developments, and wildlife area improvements, and accomplishment of such practices by 29,020 additional district cooperators in the basin had been planned by the State Conservationist. The lack of accomplishment by the latter group was caused by inavailability to the State Conservationist of sufficient technicians and not by unwillingness of the group to carry out conservation plans.

WATERSHED MANAGEMENT

40. The Neuse River Watershed Authority was created by the General Assembly of North Carolina in 1953 for the purpose of promoting the mutual interests of the several counties, towns, cities, and communities in the basin pertaining to flood prevention, regulation of stream channels, land reclamation, irrigation, conservation of water, regulation of stream flow, water supply, disposal of sewage and other waste produce, and arresting erosion.

41. The Authority held two organizational meetings in 1954, at the latter of which action was taken toward undertaking a survey of the basin to serve as a basis for accomplishment of its purpose. It is anticipated that this publication and Chapter XIII of its predecessor, "Water Resources of North Carolina", will assist the Authority in attainment of its objective.

NAVIGATION

42. The Corps of Engineers, U. S. Army, has completed construction of three navigation projects in the Neuse River Basin, namely, Bay River, Swift Creek, and Contentnea Creek. The Neuse River navigation project is complete, except that the width of the channel at New Bern is 200 feet, whereas the authorized width of this channel is 300 feet. The Trent River navigation project is complete, except that no work has been done, on the boat and repair basins, with access channels thereto, at New Bern. The District and Division Engineers, upon completion of an investigation to determine the feasibility of an alternative location of the authorized boat and repair basins, with access channels thereto, recommended no modification of the authorized project.

FLOOD CONTROL

43. The Neuse River and its principal tributaries are all of a very meandering type, which causes their flood waters to be discharged very slowly. The numerous turns and bends also have a tendency to increase

their roughness coefficients and thus decrease their carrying capacities. These adverse effects are partially compensated for by the additional valley storage that this type of stream provides.

44. Large floods occurred on the Neuse River in 1865, 1877, 1887, 1901, 1908, 1919, 1924, 1929, 1934, and 1936. Floods on this river are most likely to occur in February or March but have occurred during every month of the year. They are least frequent in November. It also appears that the higher stages are likely to occur in the summer and early fall.

45. The maximum flood of record at Smithfield (that of August 1908) had an estimated gauge height of 27.1 feet (13.1 feet above flood stage). It is believed that a flood flow 100 per cent greater than the maximum obtained during the period of record at Smithfield may sometime be expected. Such a flood would obtain a stage of about 35 feet at that point and would cause heavy losses.

46. The Chief of Engineers, U. S. Army, after investigation of the Neuse River and its tributaries for navigation, flood control, and other purposes, including preparation of a plan for construction of storage reservoirs, at the Falls of the Neuse and Wilson Mills on the Neuse River, Bakers Mill on the Little River near Princeton, and Wiggins Mill on Contentnea Creek, near Wilson, reported to the Congress of the United States on May 31, 1932 that, while construction of flood control reservoirs in the Neuse River Basin was economically justifiable, the cost of such a project was greater than the sum that could be assessed against the lands benefited; that the project was not, therefore, economically advisable in the sense that it would be self-supporting; and that the general benefits from the flood control project were not sufficient to warrant Federal participation in the cost.

47. The Chief of Engineers, U. S. Army, after investigation of the Neuse River with a view to improvement for navigation and flood control between the Johnston County line and New Bern, recommended to the Congress on May 9, 1941, that a cut-off channel, extending 6,400 feet across the bend in Neuse River just above mile 95 near Goldsboro be provided for the control of floods. The Congress authorized the project as recommended and appropriated the necessary funds for the construction thereof. The project was completed in May 1948 at a cost of about $50,500 to the Federal Government and $16,400 to local interests, including the cost of a bridge across the cut-off.

48. Emergency flood control work, consisting of clearing and snagging Trent River between mile 38 and mile 75 above the mouth at New Bern, was performed by the District Engineer, Wilmington District, during the Fiscal Year 1952, using a Federal allotment of $50,000 and a contribution by local interests.

49. Preliminary examinations and surveys by the Corps of Engineers, U. S. Army, pertaining to flood control on Cove Creek, a 35-mile reach of Neuse River between Smithfield and Wayne County line, and Neuse River and tributaries, are under way.

CHAPTER XV - - RECOMMENDATIONS

In view of the conclusions contained in Chapter XIV, the following recommendations are made:

1. That municipal governments in the Neuse River Basin, bearing in mind the fact that the per capita use of water is increasing rapidly and that most problems, connected with water shortages that have occurred in recent years have resulted from inadequate original planning or of increased demands outrunning the expansion of facilities rather than from droughts, take appropriate action to store water in times of abundance in order to provide for requirements in times of scarcity.

2. That farmers in the basin, who have not installed irrigation systems, consider the possibility of obtaining additional revenue from profits resulting from use of water to irrigate crops, and take action, where appropriate, to store water in surface reservoirs during high stream flows for diversion therefrom when needed for irrigation.

3. That municipalities and industries in the Neuse River Basin, before installing large ground-water supply-systems, obtain the maximum practicable information regarding the geology of the concerned aquifers and their known hydrologic properties.

4. That the Neuse River Watershed Authority take action as follows:

a. Obtain financial support for accomplishment of its purpose through membership dues; contributions from private organizations, such as chambers of commerce, civic clubs, and sportsmens' clubs; and funds from political units as provided in Section 3 of the Act of the 1953 Session of the General Assembly of North Carolina which created the Authority.

b. Make, in collaboration with other agencies, a careful study of the watershed and of the current problems therein.

c. Advertise the available services of the Authority and encourage people to use them.

d. Assist in every possible manner the formation of soil conservation districts in the Neuse River Basin, where needed, and promote and accelerate the work of existing districts.

e. Cooperate with schools and colleges, and with other agencies, as indicated on page 115 of "Water Resources of North Carolina", published by the Department of Conservation and Development in January 1955.

f. Avoid the mistakes set forth on page 116 of the publication indicated in e. above.

g. Carry on simultaneously constructive work on all natural resources, covering soil, forest, water, and wildlife resources, rather than concentrating on one natural resource.